Laboratory Procedures in Sanitary Milk Control*

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THE above title suggests a constructive discussion of a difficult assignment; i.e., to summarize the evidence with regard to laboratory methods for the examination of milk as represented on the one hand by the U. S. Public Health Service, and on the other by the Connecticut State Department of Health. Each complete program of control, hereinafter identified as Plan A and Plan B respectively, has its distinctive features, some of which, unless better understood, may be regarded as controversial.

When referring to fluid market milk of "high quality" or of "high sanitary quality" and when fixing minimum standards of quality for acceptable milk and cream, public health sanitary codes invariably mean, among other things, products which are free from infectious bacteria and which have, and always have had, a low bacterial content. As herein used, unless otherwise qualified, the term "milk" includes both milk and cream intended for fluid market sales. The term "quality" refers only to the bacterial condition of the sample. The term "sanitary" is used broadly to include both initial contamination with microorganisms and subsequent growth thereof.

The accomplishments should be considered, first on the basis of satisfying the minimum requirements specified under each plan, and second on the basis of the supplementary steps taken to assure conformity with the basic intent of each sanitary code. Under each plan, the administrator may require supplemental tests which are not inconsistent with the basic principles of the code and which do not lower the standards of quality or the operational procedures. Under both plans the sponsors endorse and actually encourage the application of useful quality tests which are not specifically required.

The best means to assure the safety of a supply will be discussed somewhat concisely. Because of limitations peculiar to each of the recognized procedures for estimating the bacterial content in different types of milk, the more debatable features of each method will be briefly reviewed.

Although the problem for considera-
tion is the relative effectiveness of the laboratory methods actually used to determine continuous compliance with the basic intent of the statute or code, obviously there are factors other than laboratory analyses which affect accomplishments. With the specific assignment, it is not possible to consider separately the rôle of each of these items. Because of the major rôles played by the inspection force and by the laboratory workers, it is logical to recognize these two subdivisions. Without the inspection force to investigate questionable conditions based upon laboratory determinations, the analyses would be relatively futile. Without the findings of fact, the inspection work would tend to be haphazard.

Mindful of the above considerations, it will become evident why tangible comparative evidence on achievements is practically impossible to obtain and why opinion must be substituted in part for factual evidence. Also it will become increasingly apparent that one cannot quote a few figures and percentages from reports to show with absolute fairness the actual accomplishments of control agencies. Without proper consideration of at least some of the determining factors other than laboratory analyses, this discussion would create a misconception of what constitutes sanitary milk control.

PLAN A

Under Plan A a milk ordinance and code¹ is recommended by the U. S. Public Health Service for voluntary adoption by states and communities, in order to encourage greater uniformity of milk control practices. Although subject to change as new information becomes available, Plan A represents the considered judgment of a group of technical experts familiar with various phases of the public health control of milk. To promote uniform enforcement, seminars are also arranged periodically by district Public Health Service offices to instruct both in-service and local personnel.⁷

The recommended milk control ordinance is in effect (November, 1944) throughout Nevada and Alaska, as well as in 1,001 municipalities and 150 counties and districts in 36 other states and Canada. It has been adopted as state regulations governing all milk in 15 states and pasteurized milk only in 3 other states. All graded milk must comply with Public Health Service standards in 5 states, and all Grade A milk in 4 other states. Inclusion in the complete list of subscribers to the ordinance, or to portions thereof¹⁴ does not necessarily imply that the ordinance is being satisfactorily enforced, and lack of enforcement does not bar inclusion. Enforcement is not a responsibility of the Public Health Service.

Compliance lists are published periodically, except during the war emergency, of communities which have adopted the ordinance and code and in which both the pasteurized milk and the raw milk compliance ratings are 90 per cent or more.⁸ Inclusion in this list means that the state health department, upon request for inspection by the local community, has reported that the milk ordinance in effect in that community is the Public Health Service milk ordinance without downward revisions, or changes in grade names, or significant changes in the form of the ordinance. Upward modifications are permitted, but not recommended except as necessary to avoid conflict with the state laws. Regrading and degrading schemes are proposed to reward or to penalize respectively individual producers and dealers, as the case may require. Prior to determining compliance ratings, ratings are also assigned to enforcement methods in order to make certain that determinations are reasonably uniform.⁹,¹⁰

The degree of enforcement according
to the latest published record, where all Grade A milk, both raw and pasteurized, had a compliance rating of 90 per cent or more, lists 21 communities where all of the milk was pasteurized, 124 where varying amounts of raw and pasteurized were sold, and 19 where all of the milk sold was raw.

The enforcement unit and the testing laboratory are probably in the same administrative subdivision of the governmental agencies in most cases. Where more than one laboratory is responsible to any one agency, it is probable that annual inspection of such laboratories to determine conformity to standard practices is not mandatory prior to approval. Furthermore, the uniformity of operations would be appreciably less if all of the laboratories alleged to be using A.P.H.A. methods were compared. In connection with its responsibilities for the quality of milk used on interstate carriers, the Public Health Service has in recent years assisted many state health departments in establishing uniform supervision and approval of local laboratories analyzing supplies used on common carriers. Extension of these activities should go far to achieve a high degree of uniformity in laboratory operations and to make analyses in the many communities operating under Plan A comparable to that described under Plan B.

Because the Public Health Service ordinance is placed in the hands of so many administrators, inspectors, and milk plant operators, some of whom undoubtedly are less well informed than others, more detailed directions appropriately have been published. Bulletin 220 supplies this need with 44 pages of directions for guidance when inspecting the premises of the milk producer and the milk producer-distributor and 58 pages when inspecting the operations and equipment in the pasteurizing plant.

During each grading period, which shall not exceed 6 months, each agency in order to conform under Plan A, (1) must inspect all dairy farms and all milk plants once, and (2) must examine four samples of milk and cream from each farm and from each milk plant. Various quality grades are established under Plan A for raw milk, depending upon the alternate use of standards expressed in terms of the Standard Plate Count, the Clump Microscopic Count, the Individual Microscopic Count, and the Methylene-Blue Reduction Time. The agar plate method is the only procedure authorized for use on pasteurized products. Determinations of conformance are based upon the average of four successive counts on samples from the same source taken on different days. In case determinations are made by one of the counting methods, the logarithmic average is employed.

Although the value of the phosphatase test is mentioned in a footnote and also in one of the amendments (Dec. 3, 1942), its use is not required on pasteurized products. The coliform test is not referred to. The application of sterility tests to determine the degree of sterility of the surfaces of single-service containers and container caps and covers and of milk bottles and cans is given due consideration.

When infractions of the ordinance are discovered, a farm or a milk plant may be degraded based either upon violations of operational practices or the failure to provide equipment and facilities on the premises as determined at the time of inspection or upon violations as determined by laboratory tests on the milk as offered for sale. When the violator has shown his ability to correct the infraction, then upon application for regrading the supply may be regraded. Despite guidance provided by repeated seminars, provisions for regrading and degrading milk supplies
are inevitably subject to variations in discriminatory action locally. Where judiciously enforced, undoubtedly the results will be a reasonably equitable adjustment, according to the efforts made by the producer or by the retailer. When, and if, it can be demonstrated that milk from a certain source will satisfy the quality standards as determined by suitable laboratory tests, it is distinctively debatable whether all of the mandatory facilities, equipment, and operations itemized for dairy farms and for milk plants are positively essential. Unless wisely administered, too much regimentation may occur under any plan.

Because of the wide adoption of the Public Health Service ordinance, it has been impossible to examine the records obtained in each place individually or otherwise. No doubt, in some places the enforcement is distinctively above criticism because the administrator has supplemented his mandatory determinations with additional determinations which assure both greater safety and more uniform compliance. In contrast, probably there are many who have not done so. PLAN B

Plan B represents the considered judgment of qualified control officials in Connecticut, is mandatory only in its minimum statutory requirements, and is administered by a single enforcement officer for all fluid market milk and cream consumed in the state.

The jurisdictional area is the State of Connecticut with the adjacent milk shed. The area where the milk is consumed is confined to 4,965 square miles, the population (1940 census) was 1,709,242, and the greatest distance from a producer within the state to the State Laboratory is about 75 airline miles. There are about 5,000 farms within the state that produce milk for sale. The milk shed normally includes adjacent areas in New York and Vermont.

The enforcement unit and the testing laboratory operate under two separate administrative subdivisions of the state government. The Laboratories of the State Department of Health assume the responsibility for the official examinations of all samples of milk and cream submitted by the Dairy and Food Commissioner. To aid in the work, the State Health Laboratory, after inspection and approval of facilities in other laboratories in the state to make certain specified determinations, examinations, and tests relative to the sanitary control of milk, issues certificates to certain qualifying laboratories. In 1946 certificates were issued to seven municipal laboratories and to twelve others. Annual mandatory inspection before issuing new approvals assures a high degree of uniformity among laboratory operations.

Inspections of farms and of milk plants are made under the direction of the Dairy and Food Commissioner. No minimum frequency of official inspections or of official sampling is required by statute.

Various quality grades are designated for both raw and pasteurized milk depending upon a specified average number of bacterial colonies per ml. as determined by analyses made by the agar plate method. The average means the logarithmic average of the last three consecutive samples taken on separate days. In some instances, the period of sampling is limited to an interval not exceeding 30 days and the determinations to be averaged, although they must be on "at least three separate samples," are required to be neither on samples taken on separate days nor on samples taken consecutively.

No minimum frequency of laboratory examination of raw milk to be pasteurized is required by statute but the Dairy and Food Commissioner attempts
to make examinations quarterly. About 70 per cent of the raw bulk milk is sampled and examined quarterly by the buyers and about 30 per cent is sampled and examined quarterly in the State Health Laboratories at the direction of the Dairy and Food Commissioner.16

The laboratory examines essentially all samples of milk and cream by the direct microscopic method. The agar plate method is used only in special cases, such as on certified milk and on samples, the "bacterial counts" on which are to be reported, together with other determinations, to officials in the U. S. Army. All allegedly pasteurized milk samples are routinely examined by the phosphatase test and by the coliform test. Sterility tests on equipment are made only as circumstances indicate the need thereof.

When infractions of sanitary standards are found, the common procedure is to send a warning letter to the individual responsible for the sale of the milk. After making subsequent tests or examinations, if infractions continue to exist, the individual is asked to appear at a hearing. After making a third test or examination to determine whether or not infractions still exist and such infractions continue, then the sale of the milk from the farm or from the milk plant responsible for the condition is prohibited. Such prohibitions may be temporary or permanent, depending upon the steps taken by the operator to correct the unsatisfactory conditions.

Under Plan B, the selection of a qualified enforcement official who has had both training and experience in sanitary milk control problems is reasonably assured. Conferences are arranged periodically with inspectors so as to establish as high a degree of uniformity of operations as possible.

Despite the application of special laboratory tests to all samples of import cream, there is some reason to believe that an abnormally high percentage of both raw and pasteurized cream, as judged by the records on samples examined, exceeds the standards. A record on samples of raw milk to be pasteurized shows a relatively low percentage of milk exceeding the standards. Based on samples examined, the percentage of retailed pasteurized milks which exceeded the standard was about twice as great as the percentage of violations among the samples of raw milks to be pasteurized. Obviously such percentages are subject to distortions caused by repeated examinations of samples from sources where violations have occurred or are more apt to occur.18 Among other reasons for these percentages being high are, (1) the use of the direct microscopic method which makes possible the discovery of high count samples that ordinarily would escape detection by the agar plate method, and (2) the wartime inability to make as frequent inspections of premises as are needed to assure reasonable compliance.

GENERAL APPLICATIONS AND LIMITATIONS OF METHODS

None of the routine laboratory procedures for estimating the number of bacteria in milk5, 6 will determine whether or not infectious bacteria are present. The best assurance of freedom from infectious bacteria is that provided by proper pasteurization of the milk.17–19 The best assurance of pasteurization is that demonstrated by a satisfactory phosphatase test on the bottled pasteurized milk.20–23 The best assurance of freedom from recontamination in freshly bottled milk after pasteurization is a satisfactory coliform test in 1.0 ml. portions of the bottled product.24–27 In the case of raw milk to be consumed raw, the assurance is much less satisfactory28–31 and can only be achieved in part by the careful
handling by healthy individuals of milk from cows that are not infected with tuberculosis,32, 33 brucellosis,34 etc., not suffering from pathogenic udder infections,35, 36 streptococcal, staphylococcal, etc., and in which mastitis infections 37 are reduced to the practical minimum.

The degree of careless handling of either raw or pasteurized milk is generally reflected by the magnitude of the count. Furthermore, when milk is determined to be the sole cause of the illness among consumers, it is more common to find products (with a high bacterial content) which have been subjected to careless methods of production and handling responsible for the condition than products with a low bacterial content.38

In addition to assurances of satisfactory facilities, equipment and operations at the farms and in the plants, the administrator wants to know whether or not the milk conforms with the prescribed standards as determined by laboratory examination. By the selection of methods,5, 6 the laboratory can determine objectively in raw milk the "bacterial count" and, when a high count is found, roughly the extent of and whether or-not udder infection, utensil contamination, or poor cooling are among the causes thereof. By the selection of methods,5, 6 the laboratory can determine objectively in pasteurized milk whether or not it has been pasteurized and the "bacterial count" therein and, when a high count is found, roughly the extent of thermoduric, thermophilic, and psychrophilic contamination, and the degree of poor cooling, extended storage, or recontamination from equipment after pasteurization.

When samples fail to conform and the inspector and the laboratory are near the scene of operations, the objectionable condition(s) usually can be corrected more quickly. In some cases, determinations can be made by the inspector on the receiving platform so as to prevent the acceptance of unsatisfactory milk.39, 40 Where determinations are to be made in a distant laboratory, the need for circumstantial information concerning the sample increases. Without this information, the laboratory cannot always be expected to interpret correctly the cause(s) for the objectionable conditions. Promptness in supplying correctional information so that inspections may be guided properly and without delay is essential for an effective enforcement program. In most cases, however, the laboratory director can guide the inspection force in selecting the samples so that the determinations will provide the most useful information.

RECONCILING THE CHOICE OF METHODS WITH OBJECTIVES

Because the choice of methods for bacterial estimation will depend in part upon the destined use of the product, the advantages and limitations of each of the control measures will be considered separately for, (1) raw milk to be pasteurized, (2) pasteurized milk, and (3) raw milk to be consumed raw. Since determinations are influenced by limitations peculiar to each method, implications that one method is indisputably more accurate than another are unsound.5, 6, 41-47 Because of these limitations, it is all the more important to consider the results of tests, as a means to classify the milk into 2, 3, or 4 groups or grades.13, 43 The principle of grading is distinctively applicable to supplies of raw bulk milk and may be applied with discretion to retail supplies. Where a sample falls in a lower group or grade by any one method than it does by another, it is probable that the method which places it in the better class has failed to respond to some peculiar objectionable condition in the sample which the other method will de-
tect. Mindful of these limitations, the result by each of the methods should be regarded solely as a relative "estimate" or, perhaps more appropriately, as an index figure of the true bacterial content of the sample.\(^5\),\(^6\),\(^48\)

When the colony count is determined by the agar plate method or when actual numerical counts of clumps or of individual bacteria are made by the direct microscopic method, allegorically the principle is like measuring a mile (the spread between very low count milk and very high count milk) with a relatively short measuring stick. By so doing, proper interpretations are often slighted by unnecessary attention to details both when approaching and when departing from various signposts. In contrast with such forms of measurement, the reduction type methods\(^45\),\(^46\) and a common application of the microscopic method,\(^49\) permits the rapid grading of samples into 2, 3, or 4 groups, thereby making quality grades possible on about five times as many milks per unit of time as can be made by the counting methods. Irrespective of inherent limitations of the method and of the character of the milk to be examined, some regard the microscopic and the reduction type methods as distinctively less reliable procedures than the agar plate method for marking off subdivisions of the allegorical mile. By using certain "Screening Test" modifications,\(^6\) the 5 to 1 ratio may be increased. Having obtained a quality grading first, then it is possible to spend a part of the time which has been saved directing operations to correct conditions where high counts are found. As a public health measure it is doubtful that the reporting of numerical "estimates" is strictly necessary. Where the "three out of four" method\(^6\) to determine conformance is employed, the need for numerical "estimates" is even more remote, except to make proper borderline distinctions and to provide definite values where penalty measures may be required.

Regardless of the method used to determine compliance, the classes could be selected so as to indicate to the producer or dealer, when the determinations are reported to him, (1) whether he generally has a wide margin of safety, (2) whether he is just within the "Acceptable" limit ("Acceptable," as determined by local standards), (3) whether he is a marginal violator, or (4) whether his milk is grossly contaminated.\(^6\)

RAW MILK TO BE PASTEURIZED

The procedure which permits both rapid grading and the recognition objectively of the most probable cause(s) for poor quality milk, in case high counts are observed, is the direct microscopic method.\(^6\),\(^50\) The distinct advantage of this technic is (1) its adaptability both to grading the milk promptly and, when required, to counting the actual clumps of, or the individual, bacterial cells, and (2) the opportunity it affords simultaneously in case of high counts for the partial recognition in the milk film of bacterial types and cell arrangements which are characteristically associated with (1) faulty cooling, (2) utensil contamination, (3) udder infection, or (4) some combination of two or more of these items.\(^51\)-\(^53\) Determinations may be made either in the field or in the laboratory. Although a highly skilled operator is able to draw closer distinctions about conditions associated with udder infections,\(^54\) a reasonably careful and conservative technician may be relied upon to distinguish the three conditions referred to above. Because of varying numbers of bacteria per clump, however, counts of clumps do not represent a constant proportion of the total bacterial contamination among different samples. Counts of clumps furnish a relative index of the total
bacterial content among samples.

The chief disadvantage of the microscopic technic is the fatiguing eye-strain involved chiefly where actual counts of clumps or of bacteria are made and reported. This disadvantage is enhanced by the bacteria-per-field distribution variable which potentially increases in magnitude as the bacterial content decreases. Although this variable appreciably influences replicability among "estimates," it can be controlled in part by the number of fields examined. Ordinarily this variable need not be alarming because, strictly as a public health measure, actual estimates are required only in marginal cases to assure proper grade distinctions, or in special cases for averaging counts, or in case records may be used for court testimony. Stained milk preparations may be preserved indefinitely for purposes of reference, as demonstrations in court, check counting by other analysts, etc. Mindful that only 0.01 ml. of milk is spread over a 1 sq. cm. area and that the amount of milk solids recommended for routine examination, when grading, varies from about 0.000002 to 0.00001 gm., it is amazing that different operators can duplicate results by the direct microscopic method as closely as they do. Failure to use the method in the most skillful manner possible is often credited as a limitation of the method.

Where tradition is a major influence, the agar plate method will be used to determine the bacterial condition in milks intended for pasteurization. The plate method is distinctively a laboratory procedure. About thirty years ago, its use was sanctified by a vote of confidence as being less subject to errors than the direct microscopic method when used as an index of total bacterial contamination. Although still masquerading occasionally as a "total count of the bacteria present," determinations by the agar plate method have served almost since quality control began as an unprecedented guide for health departments to establish and to maintain quality grades of milk. Despite its limitations, the method has served well as a relative index of bacterial densities. The amount of milk deposited per plate varies from 0.0001 ml. (sometimes 0.00001 ml.) to 0.1 ml. Determinations are available only after the plates have been incubated for 48 hours, which in most cases is after the milk has been consumed. Only clumps containing viable bacteria will form colonies on the plate, and even these bacteria must be of a type which will form detectable colonies on the specially selected agar when incubated at an arbitrarily chosen temperature.

A count of the colonies, even if each clump formed a colony, would not represent a constant proportion of the total bacterial contamination among different samples of milk. Since the plate method fails to permit recognition objectively of the most probable cause(s) for high counts, when high count samples are recorded, the microscopic method may be used most satisfactorily for this purpose.

On low count milk the plate method can often be used with greater satisfaction than the other methods because the disadvantages of the microscopic and reduction type methods exceed the limitations of the former. As the counts continue to decrease, the corresponding advantages of the direct microscopic method increase to the point where its use is preferred to that of the other procedures. This point is often debated in case of the direct microscopic method. Obviously it depends almost exclusively upon the skill and willingness of the operator to use the microscopic procedure as it can be used as a counting technic. In proven low count milk the bacteria-per-clump variable is usually low, thereby increasing potentially the replicability among
"estimates" by the plate method, while the bacteria-per-field distribution variable increases as the counts become lower, thereby decreasing potentially, unless additional fields are examined, the replicability among "estimates" by the microscopic method. On first consideration, it appears desirable to use the method which provides minimum variance among replicate observations. If minimum variance alone were a true index of the reliability of methods to determine bacterial density, the reduction type methods would be used exclusively.

The reduction type methods offer the simplest form of grading tests recognized and are particularly adaptable where funds are limited. More samples can be graded per unit of time by the reduction methods than can be classified by any of the other procedures. Although the application is distinctively limited to classifying samples as to grade, both the methylene-blue reduction method and the resazurin reduction method are applicable within reason to all quality grades of raw milk.

The amount of milk subjected to the test is 10 ml., which varies from 100 to 1,000,000 times the volume actually examined or tested when other recognized methods are used. Because the decolorization of the dye is influenced by the growth of each individual cell in so far as it is able to consume oxygen, determinations by the reduction methods may be expected to parallel closely the actual degree of contamination. Since each of the reduction type methods fails to permit recognition objectively of the most probable cause(s) for high counts, when short reduction time intervals are recorded, the microscopic technic may be used most satisfactorily for this purpose.

Because coliform bacteria may be derived from such a variety of sources, because their presence in milk is not necessarily indicative of fecal contamination, and because their rate of growth is roughly proportional to the rate of growth of the majority of the bacteria present, tests to determine their presence in raw milk intended for pasteurization and thereby to supplement determinations made by the counting, grading, and reduction type methods, are of little or no additional significance. A special interpretation is applied to the presence of coliform types of certified raw milk.

PASTEURIZED MILK

In addition to the common advantages and disadvantages outlined for the microscopic method under applications to raw milk, this method permits the detection of abnormal conditions in pasteurized products which otherwise would escape detection. Dead and partially plasmolyzed bacterial cells in the films may retain their staining properties in varying degrees in freshly pasteurized milk, but such milk, when examined more than 6 hours after pasteurization, ordinarily will disclose so few bacteria which have been killed during the heating process that any such organisms, if present, will constitute an insignificant portion of the total number of stainable bacteria present. Some have called attention to the misconception regarding the presence of the so-called dead bacteria. Although others have directed attention to the presence of the so-called "thermophilous bacteria" in pasteurized milk, apparently this idea was forgotten when methods for determining conformance to standards were considered. There is good reason now to believe that many of the stainable, assumed-to-be-dead, bacteria in the films were living bacteria which failed to grow because the agar and incubation temperature would not permit their growth.

Some who find pasteurized milk sup-
plies to be satisfactory by the direct microscopic method may interpret from such determinations that all of the raw milk before pasteurization necessarily must have been satisfactory also. Obviously this is a false assumption and the same would be equally true if the results of tests by the agar plate method or by the reduction type methods had been satisfactory. Unless records are obtained to show that the raw milk to be processed conforms to regulations, no pasteurized milk supply can be regarded as adequately controlled.

In general, the common advantages and disadvantages outlined for the agar plate method under application to raw milk, apply also to pasteurized products. Despite its limitations, as referred to previously under raw milk to be pasteurized, the method can often be used on proven, very low count samples with greater satisfaction than the other methods because the disadvantages of the microscopic and reduction type methods often exceed the limitations of the former. In addition to determining the cause(s) of high counts by means of "line tests" and by the direct microscopic method, additional plates, when microscopic observations indicate the need thereof, should be incubated at appropriate temperatures to permit the growth of thermophilic and psychrophilic species and of bacteria that survive pasteurization.

Although a modified application of the methylene-blue reduction methods, promulgated by the Ministry of Health, March 1, 1946, is used in Great Britain, this application to pasteurized products does not seem feasible in America. Thus far, the resazurin reduction method has not been found satisfactory on pasteurized products.

Unless phosphatase tests are made at regular intervals and, when a positive determination is discovered, additional samples from the same source tested until it is assured that results may reasonably be expected to continue to be satisfactory, no pasteurized milk supply is adequately protected.

Where coliform tests on freshly bottled pasteurized milk show positive determinations in 1.0 ml. quantities, no pasteurized milk can be regarded as satisfactory. Since coliform species are invariably killed during the heat treatment, their presence in the freshly bottled product constitutes an unusually delicate test for recontamination, usually from the equipment somewhere between the pasteurizing and bottling operations. As the interval between bottling and the time of testing increases, it becomes increasingly difficult to determine objectively, when positive tests are discovered, whether the cause thereof was initial coliform contamination or subsequent growth of such contamination.

Where questionable procedures are used to sanitize the dairy utensils or the milk plant equipment, sterility tests may be used advantageously to disclose the exact piece of equipment which has been subjected to faulty sterilization.

**RAW MILK TO BE CONSUMED RAW**

The applications of the several quality test methods, as outlined under raw milk to be pasteurized, are equally applicable to raw milk to be consumed in the raw state. Because such milk is not protected by any heat treatment, it is essential that more frequent inspections of the producer's premises and of the equipment, personnel, and methods at the milk plant be made. Furthermore, the milk should be produced by animals which are free from bovine tuberculosis, brucellosis, and other diseased conditions, and come from udders that are free from infection.

**DISCUSSION OF APPLICATIONS**

Without an exhaustive study of
records and without at some time taking an active part in the operations under each plan, it is impossible to summarize completely the importance of all of the operations and achievements. However, certain items are more outstanding than others, among which are the following:

1. Enforcement of the Public Health Service ordinance is a responsibility of the subscribing authorities. Some jurisdictions not listed in the 90 per cent conformance group undoubtedly are providing a higher assurance of safety than some that are listed. Some jurisdictions that are on the complete list obviously are not enforcing the essential provisions of the ordinance. Other jurisdictions may be enforcing the ordinance but have not solicited certification thereof. Undoubtedly many jurisdictions in the Americas, exclusive of those subscribing to the Public Health Service ordinance, have identical objectives and have equally as effective enforcement as those in the 90 per cent or higher conformance rating group. There are others where the reverse is true. Without enforcement even the best control plan becomes worthless. Without periodic ratings of enforcement methods, neither uniform enforcement nor compliance with standards can be assured among different jurisdictions.

2. *Bulletin 220* of the Public Health Service commendably provides a uniform basic guide for less well informed officials on many items essential in sanitary milk control. Supplemented by seminars provided by district Public Health Service offices to promote uniform enforcement by both in-service and local personnel, Plan A makes possible as high a degree of uniform enforcement as is reasonably obtainable under a volunteer adoption system. The Public Health Service, except as needed to provide milk for interstate carriers, has essentially no persuasive control in the various jurisdictions subscribing to the ordinance except that engendered by publication of the results of accomplishments, i.e., by listing communities in which all Grade A milk sold therein has a 90 per cent or higher conformance rating with the standards prescribed. Enforcement methods are rated prior to determining compliance ratings. A listing periodically of those communities, at least by appropriate groups, according to the degree of compliance would be expected either to provide more uniform local enforcement or to retard adoption in communities where enforcement of the ordinance is apt to be less effective.

3. Several jurisdictions have supplemented the basic requirements in the Public Health Service ordinance by requiring the routine use of the phosphatase and coliform tests on all pasteurized milk and cream samples and thereby have provided a greater assurance of safety.

4. By stipulating that the agar plate method is the only one recognized for determining the conformance of pasteurized milk with the standards, the ordinance wholly ignores the possible detection of an appreciable number of samples which may contain large numbers of bacteria that fail to produce detectable colonies on the plates.

5. The requirement in Plan A that four samples of producer's milk shall be examined by an official agency during each 6 month period places a heavy burden upon finances and personnel in the respective administrations, especially those with large milk sheds. Because of the essential need for repeat samplings and repeat inspections in cases where samples fail to comply, the cost of control to provide 90 per cent compliance ratings may become almost prohibitive. The cost to public agencies can be reduced by placing a part of the routine responsibility on the licensed purchasing agency for inspecting producer's premises and for ex-
amining samples and maintaining each supply in an acceptable form.

6. Under plan B, essentially all bacterial estimates to determine compliance are reported in terms of clump microscopic counts. Since the original law as well as the rules and regulations adopted by the Milk Regulation Board provide minimum standards for quality in terms of "standard plate count bacterial colonies," and since there is no record that either body, but more especially the legislature, has modified its original intent of the precise manner in which compliance shall be determined, it is doubtful that conformance is determined legally in the State of Connecticut unless tests are made by a method which provides for expressing the results directly in terms of "standard plate count bacterial colonies." There is no record that the legislature has reconsidered or that it has authorized the use of substitute standards for the equivalence in quality in terms of results by another method.

7. The manner of reporting by the Laboratory of the State Department of Health in terms of clump microscopic counts was agreed upon as acceptable to the Dairy and Food Commissioner. Probably results of tests by the two methods have been compared to show the fairness of the clump microscopic count standard as an interchangeable measure of quality with the legislative standard for proven low count pasteurized milk. The standard clump microscopic count in terms of 200,000 per ml. for retail Grade A raw milk probably is a liberal interpretation for the equivalence in quality of the legal agar plate count standard. The use of the microscopic method is not criticized but the specific authority to ignore the statutory provisions appears to be lacking.

8. Records would indicate a distinct need for more frequent routine sampling. This applies both to producer's milk and even more particularly to the retailed milk and cream. The repeated finding of more than 10 per cent of the samples which fail to comply indicates that the cause for the high count, perhaps influenced by relapsing tendencies in the plant between samplings, has not been eliminated.

9. Some methods of examination reveal more promptly and more completely than other methods the information needed, e.g., whether or not the bacterial content is excessive and, in case of a high count, the most probable cause(s) thereof. Despite the value of prompt determinations, the need for a reliable index figure of the total bacterial population cannot be ignored. The use of methods which delay reports and which lack completeness is not always consistent with the basic intent of regulations. When it is established that more useful methods can be judiciously employed to speed up determinations, to assure a higher degree of safety, and to indicate more consistently the total bacterial population in the milk, it is distinctively a responsibility of the administration to provide for amending such inflexible portions of the regulations as may obstruct the accomplishment of the basic intent of the code.

10. Where a quality standard for a product is fixed in terms of results by two or more methods, the official standards should be interchangeable in so far as it is possible to make them so.

11. Since the values obtained by any of the official methods do not represent an actual count of the bacteria present, or even a constant proportion of the bacterial contamination in the samples, the results of determinations may be looked upon essentially as relative index figures of the true bacterial content of the sample. For this reason the figures so obtained can more logically be grouped into grades or classes indicating major differences in
sanitary quality instead of being regarded with mathematical precision. In the absence of precise values, instead of averaging the determinations, the use of the "3 out of 4" method, in order to ascertain compliance, is a simple and practical substitute for averages. As a public health measure, the need for reporting actual numerical "estimates" of the bacteria may be confined chiefly to borderline cases to assure proper grade assignments and to the preparation of records where court testimony may be required.

12. Where determinations in the form of "estimates" are needed, frequently those made by the plate method, especially among proven low count samples, vary less among replicate values than those commonly obtained by the microscopic method. Where a sufficient number of fields are examined, this variance among replicates, even on proven low count samples, may be reduced, if needed, so that it does not exceed that obtained by the plate method. When samples which supposedly have a low count as determined by the plate method are examined microscopically and are proved to contain appreciably more bacteria than the "Standard Plate Count" discloses, the importance of replicability among plate counts as a measure of reliability to determine conformance is distinctively reduced. Furthermore, a high variance among replicates has never been shown to jeopardize public health. Despite the relapsing tendency to regard replicability among counts as synonymous with accuracy, the agar plate method will continue to be a useful procedure for indicating the degree of contamination in proven low count milk.

CONCLUSIONS
Under either the U. S. Public Health Service Ordinance and Code (Plan A) or under the Connecticut State Department of Health Program (Plan B), the fundamental objectives of maintaining the highest possible assurance of safety and continuous conformance to the standards for low count milk have not been as fully achieved as might be expected.

Plan A would be improved by:

1. Requiring the routine testing of all samples of allegedly pasteurized milk using the phosphatase test and the coliform test.
2. Requiring a microscopic examination of all raw samples which fail to comply, especially when field inspectional methods fail to disclose the cause for high counts or short reduction times.
3. Requiring routinely a microscopic examination of all pasteurized samples to determine whether or not high count samples escape detection by the plate method.
4. Permitting the use, where determinations have been checked periodically and found satisfactory, of routine plant reports on inspections and analyses of samples by licensed purchasing agencies in lieu of official inspections and analyses.

Plan B would be improved by:

1. Securing proper legislation fixing, or allowing the Dairy and Food Commissioner to fix by official order, standards for bacterial density in terms of results by methods which are to be used officially for the determination of compliance with the statute.
2. Providing for more frequent routine inspections and examinations of samples, with prompt repeat inspections and repeat examinations of samples in cases of non-compliance until continuous conformance can be reasonably assured.

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