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Editorials

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PUBLIC HEALTH SERVICE DISEASE REPORTS, 1947

CONTINUING the simple tabulation of last year, for purposes of rough comparison, this is the way the record looks with 1947 added:

	Number of Outbreaks			
	1944	*1945*	*1946*	*1947*
Milk and milk products	36	24	12	17
Ditto, suspected	5	5	6	5
Other foods	288	272	287	292
Ditto, suspected	10	3	12	24
Water	...	20	25	20
Ditto, suspected	...	6	7	4
Undetermined vehicles	...	12	6	27

MILK AND MILK PRODUCTS

Of the 17 outbreaks, reported from 7 states, 14 were gastroenteritis or food poisoning, one paratyphoid, and two typhoid fever. Five outbreaks, 3 food poisoning and the 2 typhoids, were charged to sweet milk. Carriers on dairy farms were responsible for the typhoids. Three cases of food poisoning were from one bottle of New York City pasteurized milk which, apparently, was contaminated after pasteurization.

Four outbreaks of food poisoning or gastroenteritis and one of paratyphoid B infection were traced to home-made ice cream. The ice cream involved in one of the so-called food poisoning outbreaks (salmonella), which was prepared for a church supper, was made from pasteurized milk but it is a reasonable assumption that the contamination came from sources other than the milk.

Home-made cheese was responsible for what were listed as five outbreaks of food poisoning. Four of these, however, 16 cases in all, came from the same lot of cheese and could well have been listed as one outbreak. Two outbreaks of food poisoning, 3 cases each, were attributed to buttermilk and condensed milk, respectively. The latter had been open and exposed to contamination. Except as already noted no pasteurized products were involved in any of the 17 outbreaks. The reports came from Arkansas, California, Kentucky, Maine, Michigan, New York, and Oklahoma.

An outbreak of 50 cases of typhoid fever, stemming from an Illinois filling station and included in the "Suspected" list belonged, in the snap-judgment of this writer, in the positive list. Ice cream, including cones, was handled and sold by a typhoid carrier and the evidence that the infection was conveyed

through the ice cream seemed practically conclusive. Dozens of outbreaks have been placed in positive lists on evidence less clear.

Foods Other Than Milk

Of the 292 outbreaks listed (not including "Suspected") 24 were of food infection, the diseases involved being 4 typhoid fever, 15 paratyphoid or salmonella infection, 2 bacillary dysentery and 3 trichinosis. The rest were food poisoning, under one name or another. Botulism occurred 12 times including, as we apparently must, 4 "outbreaks" of a single case each. All were from home-canned products: vegetables 10, fruit 2. Washington reported 4, California 3, New Mexico 2, with one case each from Colorado, Kentucky, and Maryland.

There were 6 outbreaks of chemical poisoning, 4 due to accidental misuse of poisonous chemicals: one, in a camp, apparently from silver polish left on table utensils and one of about 400 cases, in a New York State prison, apparently from caustic soda intentionally added to food. The latter was the third such episode in the same prison!

The remaining 250 outbreaks were of the "run of the mill" sort. Staphylococci were cited in 136, *aureus* specified in about half. With these, lack of proper refrigeration, quite obviously, was the Number One causative factor. Places, not including private homes, most frequently mentioned as involved in service or sale of incriminated foods, in order of numbers, were (1) hotels, restaurants, and other public eating places (number almost identical with that of last year); (2) bakeries and other stores; (3) schools and colleges; (4) hospitals and other institutions; and (5) camps. Parties in connection with which none of these places were mentioned were associated with 27 outbreaks.

Types of foods most frequently listed as responsible or suspected, in order of frequency: (1) poultry dishes, exclusive of salads, turkey most often—perhaps because it lasts longest; (2) meat dishes, other than poultry and ham; (3) pastries, usually specified as custard or "cream" filled; (4) ham, usually cold ham combinations; (5) salads, most often potato or chicken; (6) sea foods—in a small number.

Water

Twenty outbreaks were charged to water: 15 gastroenteritis and 5 typhoid fever. Only 2 of the 20 outbreaks were from treated public supplies. Both of these were gastroenteritis and involved a thousand or more cases. One resulted from temporary failure of chlorination, the other from heavy pollution due to unusual conditions. Water from wells and from polluted surface sources was responsible for most of the outbreaks.

The 11 cases of typhoid in one outbreak were among members of a cooperative rice-threshing crew. The outbreak was attributed to carriers among members of the crew, one of them a water boy. This could have been charged to indirect contact, rather than water. Fifteen of the 20 outbreaks were gastroenteritis, 12 of them reported from New York State. Nearly all of the latter were in summer resort areas and, in the earlier years, probably would not have come to the attention of the health authorities. One outbreak was among inmates of a New York State prison camp. The water supply was from a brook and untreated. Samples taken at various times previously had shown contamination. This was the same prison in which sabotage had resulted in three consecutive outbreaks of chemical food poisoning. Water outbreaks were reported from 6 states (California, Louisiana, Massachusetts, Nebraska, New York, Virginia) and from Alaska.

Undetermined Vehicles

Twenty-seven outbreaks were listed under this head, 22 of them gastroenteritis. Of the other 5, two were typhoid fever, one infectious hepatitis, and two were reported as "dysentery". One of the latter was bacillary dysentery, the other apparently should have been reported as gastronteritis. The outbreak of infectious hepatitis was reported from New York State. It is of interest to note that the A.P.H.A. handbook on "Control of Communicable Diseases" (1945) says the mode of transmission is unknown and makes no mention of milk, food, or water as possible vehicles. The writer is informed, however, that there is new evidence which is likely to be considered when the next edition is prepared.

General Comment

During 1947, so far as the reports show, 37 states had no outbreaks from either water or milk and milk products: a truly remarkable record!

As for outbreaks from foods other than milk and milk products, a glance at our opening tabulation reveals a continuance of noticeable uniformity in the totals—not including the "Suspected" list. This is unimportant but, considering the fairly large totals and the number of states reporting, rather interesting.

The thorough investigations of unusual prevalences of gastroenteritis which have been made in some areas in recent years have thrown a great deal of light on the nature of these "prevalences". It has become clear that they represent epidemics or "outbreaks" from common, determinable and, frequently, preventable causes. While the possibilities of discovery have not been exhausted, the usual causes of outbreaks of the commonest types of food poisoning and infection are now well known. Outstanding among these, for example, is the combination of contamination of food with staphylococci and lack of proper refrigeration.

In at least one area in which a great deal of time and effort has been given to detailed investigations on such outbreaks, the question has been raised whether, the causes being well known, a considerable part of such time and effort would not be more profitably spent in educational activities directed toward prevention. This is a question which, in such areas, at least merits thoughtful consideration. In the meantime it seems safe to assume that the purpose of publication of the Public Health Service reports is not to provide good reading for those interested in such matters but to encourage and promote prevention.

P.B.B.

SANITARY MILK CONTROL IN RETROSPECT*

MAN only is privileged to review the past and to anticipate the future. I think I may claim the destinction of being one of the charter members of that ancient, mythical order of unorganized sanitarians, known forty or more years ago as dairy inspectors. It was in 1907, when I, an employee in the Dairy Department at Cornell University, was delegated to inspect the dairy barns and to make periodically chemical and bacterial examinations of the milk supply of the city of Ithaca, New York.

My initiation required more courage and determination than was at first anticipated, because the instructions finally were to inspect the dairy barns during the morning milking period. That was in the horse and buggy days and many dairymen started milking at 4:00 A. M. Since I had done the milking for eight years on the home farm this assignment was undertaken, nevertheless,

(* Written at request of Editor for observations on the development of milk inspection from the perspective of forty years experience.)

with the enthusiasm characteristic of youth. This was the first major responsibility to be experienced. Official milk control was in its budding stage. A new and unexplored field was opening up, which surely would offer opportunities for trained men. Three reactions in particular, among many others, stand out four decades later with peculiar vividness.

The first reaction of all was experienced at the third dairy barn inspected, when a muttered remark was overheard about these, "white-collared S. O. B.'s. who think they can tell us how to run our dairy". I may possibly have been the first inspector to be thus labeled, but certainly not the last. Being unable to retaliate, that doubled-barreled insult nearly shattered my enthusiasm. It became at once apparent, however, that forebearance, tact, and diplomacy would probably accomplish more in the long run toward improving milk supplies than would the exercise of police power, which at that time was wholly imaginary.

The second reaction, which came a few weeks later, proved most disturbing. After tabulating comparatively the first lot of data collected in the inspections, it was discovered that there appeared to be no discernible correlation between the quality of milk as determined in the laboratory, and the "score" of the dairy barns. This was absolutely contrary to what was being taught on the Hill and by public health officials. Such a revelation was wholly unexpected; it wasn't supposed to happen, but it did, and did so repeatedly. As a reminder, this same lack of correlation still exists in 1949 for reasons long ago established in research and by years of observations in practice.

The third reaction was an unexpected jolt. It came when, in a moment of consternation, an explanation of this contradiction to teaching and to scientific thinking was sought from one of the instructors. To this query came one sharp answer: "Young man, your job is to submit your reports and to keep your damned mouth shut." This one indiscreet reply actually precipitated a determination to go beneath the surface of the milk control problem in a search for the facts, if ever the opportunity presented itself.

The milk problem was definitely becoming a problem of public interest. It was, however, but an infant—a seemingly unmanagable waif about whom little was known. Because of the disease aspects involved, public health officials had already assumed full responsibility for its guardianship. This act in itself, however, officially labeled the fluid milk problem to be fundamentally a public health problem. Despite the acknowledged occasional but potential dangers from communicable diseases, this was a distortion at the outset. Distortions have a way of persisting through the years, even through the centuries.

We dairy inspectors drove over hill and dale (for that is the topography of Tompkins county) armed with the latest invention—the dairy barn score card and good intentions. We earnestly endeavored to impress upon the minds of the naturally skeptical milk producers, the public health significance of each of the hundred or more demands specifically written into the ordinance or on the score card. To these were added our own variable interpretations of any given situation, our suggestions, indeed our personal whims and fancies. In 1949 the latter virtually have all of the force of law.

Little did we realize that most of these printed demands represented the opinions of "experts", and that the health and quality aspects of a great majority of them had never been proven. The claims of "potential public significance" where no true significance had ever been established, however, quite effectively discouraged any producer who was tempted to challenge.

During these nearly fifty years there was witnessed a stupenduous evolutionary change in the dairy industry. The samples of milk in 1907 were pipetted

out of the cans at the time of delivery on the street. There were rumors about the delivery of milk in glass bottles.

From the nearby, local-producer-distributor, raw-dipped-milk era of the so-called gay nineties, the dairy industry has developed into the internationally organized industrial colossus of the mid-twentieth century. Instead of the isolated milk shed for each municipality, we now have an overlaping of competing milk sheds, extending out thousands of miles. Fluid milk has long been shipped from the north into the deep south. According to reports, it is now being transported by plane from the state of Washington to Fairbanks, Alaska. The public milk problem of 1949 has become consequently a complex of factors of which freedom from communicable diseases is but one.

The grading of milk was instituted in New York City in 1912. There has persisted, however, over the decades, a conflict in concepts of quality in milk. The consumer has thought in terms of a clean, cold, palatable, nutritious bottle of milk. She buys milk, not dairy barns or milk plant equipment. The health official has thought of quality chiefly in terms of freedom from diseases.

The consumer expects the milk and the products made from it to be safe, irrespective of the grade label. She purchases grades of meat, but she expects them all to be equally safe. The thinking consumer finds it impossible to understand the strange philosophy of grading milk, by implications or otherwise, according to varying degrees of safety: Grade A, most safe; B, less safe; C, still less safe; D, dangerous; even though all four grades might be properly pasteurized and in every other respect conform to the consumer's concept of quality.

From two years experience on milk routes I learned how bad psychology can hamper salesmanship. Imagine the handicap under which any milk salesman works when forced to sell under the above erroneous philosophy of grading one of nature's most important foods. It is easy to see how it would be infinitely easier to approach a prospective customer on some such basis as, for instance: "We have for sale three grades of milk, one richer in food value (5.0% fat), one less rich (3.5 % fat), and one vitamin D homogenized. All three are produced and processed under strictly sanitary conditions, properly cooled and are as clean and as safe as is humanly possible to make them." This is a point of view to which those of us interested in sanitary, safe milk should give some serious thought.

Milk grading is a marketing function, just as is true with the grading of all food commodities. The public health official is neither by training nor experience qualified to outline and to supervise the grading of any food in accordance with the consumer's defensible concept of quality. This is particularly true under modern day complex system of food production and distribution. In the last analysis, it is this concept of the consumer and her capacity to pay that determines the success or failure of any grading plan. The sooner it is realized that the official grading of milk on the basis of varying degrees of public health significance is a legalized illusion, the better it will be for the official sanitarian in the discharge of his functions and above all the better it will be for the industry.

The food sanitarian will have his capacities taxed to the fullest in the performance of his true functions; namely, that of insuring proper sanitary procedures to safeguard food supplies. Despite all of the deficiencies which can be easily pointed out, however, in any sanitary food control policies, there are probably no more sanitary nor safer food supplies to be found anywhere in the world than in the United States of America, thanks to years of educational effort on the part of many agencies—and in this the industry deserves its proper share of the credit along with that due the sanitary control officials.

James D. Brew

KANSAS ASSOCIATION OF MILK SANITARIANS

THE application of the Kansas Association of Milk Sanitarians to become an Affiliate of the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, INC., has just been approved by the Executive Board. Certain technical matters such as adjustment of calendar year postpones the effective date of union to January 1950.

We welcome any help in advancing milk and food sanitation, but we are especially encouraged when an organization goes all out for the cause and does not pull its punch. It is said that a man is known by the company he keeps. We have observed that this is true also of organizations. So we commend this fine group for throwing in their lot with us. Our objective of helping to insure a safe and clean and otherwise high quality food supply is worthy of the highest endeavor. None who spend their lives in such work become wealthy in a financial way, but we do have the satisfaction of knowing that we are enriching the lives of many people by making possible the availability of better food—and saving some lives. This work will be increasingly effective as all efforts therein become better coordinated. Association advances the cause.

J.H.S.

Roster of Sanitary and Public Health Engineers

The American Public Health Association, in cooperation with the National Security Resources Board, is preparing a roster of sanitary and public health engineer citizens of the United States. This roster, to a great extent, will supplement and bring up to date the roster prepared by the War Manpower Commission. Its uses will be manifold, but the immediate interest of the National Security Resources Board in such a roster is to provide a means by which trained sanitary and public health engineers can be assured of proper utilization of their professional training should another national emergency arise. The Engineering Section Project of the American Public Health Association is directly responsible for the collection of data and preparation of the roster.

On July 1 the distribution of questionnaires to be used in gathering basic information necessary for the preparation of the roster was begun. Previous to printing the questionnaire in its final form a proposed draft was distributed to a hundred engineers as a trial to check its applicability and the clarity of presentation. The final questionnaire has been prepared on the basis of the original one, plus comments and suggestions received during this trial period.

The definition of a sanitary engineer prepared by the National Research Council in 1943 is being used as a basic description of individuals who should receive and complete the questionnaire. Judgment as to whether or not the individual meets the requirments as set forth by the National Research Council in its definition will rest with each individual. The Engineering Section Project is not in a position to judge individual cases.

The files of the War Manpower Commission are being used as a basis for a mailing list in sending out the questionnaires. The Surgeon General of the U. S. Army has also supplied a list of all engineers who served with the Sanitary Corps of the Army. These two lists are being amplified by information obtained from membership lists of several of the national engineering societies, plus information submitted by state sanitary engineers through the cooperation of the Conference of State Sanitary Engineers, by larger consulting engineers and several other individuals consulted individually. It is recognized, though, that no single source of information is available for the preparation of the master mailing list. Many engineers are not registered with state boards of registration. Likewise, many are not members of national engineering organizations. As a result, it is likely that many qualified engineers will not receive the questionnaire. It is important for each sanitary or public health engineer to act for himself in the matter. Any engineer who does not receive a copy of the questionnaire within the next two or three months should notify the Engineering Section Project, American Public Health Association, 1790 Broadway, New York, so that his name can be entered in the master file and a questionnaire sent to him. In this way his name can be included in the roster.

Since the basic data collected in the preparation of the roster will remain the property of the American Public Health Association, it is planned to make certain basic information available to engineering societies and organizations cooperating in the preparation of the roster.

THE AVERAGE PLATE COUNT RATIO AS A MEASURE WITH WHICH TO JUDGE LABORATORY WORK IN EXAMINING DAIRY PRODUCTS *

AN EVALUATION OF U.S.P.H.S. RECOMMENDATION THAT AVERAGE COUNT RATIOS SHOULD NOT BE OVER 2.0 FOR THOSE SAMPLES FOR WHICH TWO DILUTIONS SHOW BETWEEN 30 AND 300 COLONIES

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INTRODUCTION

THAT there are great variations in the technique used in making standard plate counts of dairy products is emphasized by the survey of 408 milk laboratories conducted by Dr. Luther A. Black.[1] The results showed that the standard plate count was used in 399 of the laboratories surveyed. Not one laboratory, at the time surveyed, conformed to all the requirements of Standard Methods[2] on technique. Dr. Black states that those tests used primarily for sanitary control are, in general, a minor interest of many public health laboratories and do not receive the consideration due them.

This disregard for laboriously prepared aids to accurate and standardized results is not limited to failure to comply with Standard Methods. The 1939 *Milk Ordinance and Code*[3] stipulates that state representatives should determine certain data each grading period as a part of their records. One item to be determined is the "Average of the count ratios of those samples for which both dilutions show between 30 and 300 colonies. This should not be over 2.0." The average is described as being a measure "with which to judge the work of the laboratory." These statements have been included verbatim in the *Frozen Desserts Ordinance and Code*.[4] The count ratio is the ratio of the greater to the lesser computed plate count.[3, 4] The plate count is computed by multiplying the colonies per plate by the dilution used.[15] Although count ratios are not mentioned in the discussion of the survey by Dr. Black, the lack of state supervision is noted. However, in a personal communication dated January 15, 1946, Dr. Black[5] covers this point by stating: "In spite of the fact that it is indicated that the state representatives should determine such data each grading period, as a part of state records, I found upon visiting the various states that such data had not been obtained."

Thus it becomes evident that the almost universal intention of adhering to Standard Methods is too often not fulfilled and that, atlhough the average ratio is described in the *Milk Ordinance and Code* as being of value in judging laboratory work, the magnitude of average ratios as secured over the United States is unknown.

In the same communication are suggested the following corrective steps necessary to employ when an average count ratio is above 2.0:

1. Use the standard equipment recommended by Standard Methods.
2. The standard medium at correct pH, and suitable water blanks accurately measured should be prepared.
3. The agitation of samples and dilutions, their accurate measurement and other requirements relative to pouring plates should be followed.
4. It is essential that the plates be incubated at a temperature between 35 to 37° C., that this determination be made with an accurate thermometer in a container of liquid properly located in the incubator, as stipulated in Standard Methods.

* Taken from a thesis entitled "A Critical Study of Certain Factors Affecting the Accuracy of Standard Plate Counts in Dairy Products," Agricultural and Mechanical College of Texas, August 1948.

5. It is essential that the proper plates be selected for counting and that all colonies thereon be enumerated under adequate illumination and magnification such as the Quebec Colony Counter illustrated in Standard Methods.

It is obvious that there is need of reliable data on average plate count ratios resulting from routine plating, not only of raw and pasteurized milk, but also of cream, frozen desserts, and chocolate beverage as well. The determination of the average ratio is applied to all these products.[3, 4] Such data would either emphasize the need for and the benefits to be derived from the application of this measure of efficiency or show the value of 2.0 to be either too high or too low to be of practical value. This study was undertaken for the purpose of lowering an average standard plate count ratio known to be persisting at a level above 2.0 and to investigate certain factors related to the magnitude of this value.

An effort was made to determine how closely the technique routinely employed conformed to the above five requirements as embodied in the Survey Form for Milk Laboratories.[6] The equipment used conformed closely to requirements. The pH of media had been determined at various times to be 6.6–6.7; the allowable range being 6.6–7.0. Dilution blanks conformed, except that, owing to a troublesome precipitate, distilled water was used instead of tap water; however, toxicity tests showed no significant reduction of numbers of bacteria for periods of exposure up to 30 minutes. An effort to meet the requirements on the agitation of samples and dilutions was routine. When plating large numbers of raw milk samples, it is probable that 30 to 40 minutes elapsed between pipetting the first sample and pouring the agar. The plating of other products occasionally extended somewhat beyond 20 minutes. Other plating requirements were adequately met.

Although incubator temperatures were not recorded daily, occasional observations made on small containers of water indicated that the temperature maintained was, in general, between 35.0° C. and 37.0° C. with occasional increases above 37.0° C. It appeared that the selection and counting of plates was satisfactory; a Quebec Colony Counter was used for counting.

Close observation of technique disclosed that the measurement of portions of milk and of dilutions was inaccurate although the individuals doing the plating were unaware of it. Portions of the liquid were being carried over on the underside of the ends of the 1.1 ml. pipettes as quantities were measured for diluting and plating.

It was felt that the effect of this discrepancy was probably greater than any other failure to conform to requirements. The importance of this was further emphasized by the following statement made by Dr. Black[5] after listing the corrective steps noted above:

I might add that my observation has been that the most common reason for failure to get proper ratios when using the 1.1 ml. pipettes recommended in Standard Methods has been the carrying over of an extra drop or portion of a drop with the 1/10 ml. portion, due to failure to touch the tip of the pipette against the neck of the dilution bottle (allowing the lower side of the pipette to contact the inside of the container), so that drainage is apparently complete and excessive liquid does not adhere. Then, in placing this portion in the Petri dish it is essential that the tip of the pipette touch the Petri dish during delivery, so that the entire 1/10 ml. portion is delivered.

Consequently, it was decided to direct this investigation toward determining the effect upon the average ratio of eliminating, in so far as possible, inaccurate measurements due to clinging drops on the tips of pipettes.

Although it is recognized that a ratio exists between any two numerical counts, the term "ratio" is restricted for the sake of brevity throughout the discussion of this study to include only those ratios occurring between two computed counts on one sample when the numbers of colonies on two plates of different dilutions fall between 30 and 300.

REVIEW OF LITERATURE

The review of literature on this subject was undertaken with the objectives of tracing the origin of the value 2.0, and of bringing together in summary form the data on average ratios having accumulated since the adoption of this method of checking laboratory accuracy.

The value 2.0 appears in section 6 of the *United States Public Health Service Milk Code*[3] which is to be used as the legal interpretation of the ordinance. The 1927 edition of the *Milk Ordinance and Code* was the first edition in which the Code was included.[7]

Although he did not refer to this value in present day terms, Conn[8] in 1915, after an extensive study of variations in plate counts, stated:

After attention had been called to the points of irregularity and the laboratories had adopted methods of bringing about uniformity of technique so far as possible, the variations were very greatly reduced, the last tests showing that when sufficient care is given the variations need not be more than twofold.

The value 2.0 was arrived at through the work of Mr. L. C. Frank, Mr. C. A. Abele, and Dr. L. C. Havens during the early developmental stages of the recommended *Milk Ordinance and Code* in Alabama. Through a study[7] of 300 computed counts * on dilution plates, they "found that approximately 80 percent varied 50 percent or less of the average from the average." Therefore a variation of 50 percent was arbitrarily set as the limit within which such counts should correspond in order to be accepted as reliable. Since a variation of 50 percent of the average from the average results only when one is three times the other, a rule was put into effect in July 1925 which stated that "When the higher count is more than three times the lower, record the lower count, since this will be confirmed by the higher count." This was the basis for another study[7] extending from June 15, 1925, to January 31, 1926, covering over 3,500 platings of milk * samples. The results showed a remarkable increase in the number of samples producing ratios of less than 2.0. At the beginning, only 70 to 80 percent of the samples showed ratios below 2.0 as compared with the final three months during which "approximately 95 percent corresponded more closely than 1 to 2.00." This led to the formulation of the rule that "when one computed dilution plate count is more than twice the other, report the lesser," and to the following observation:

Briefly, *we have satisfied ourselves that milk platings in which one of the computed dilution plate counts is more than twice the other are too unreliable to be used in determining the grade of a milk supply.* For the present, the supply is credited or charged as the case may be, with the lesser count; ultimately, all such plating results will no doubt be discarded.

It appears that all the data used in the two studies discussed above were based on the general ratio (ratio not used here as previously defined) of the counts secured on the dilutions plated irrespective of whether or not both counts on a sample fell between 30 and 300. This conclusion is supported by the following statement by Mr. C. A. Abele taken from a personal communication[16] dated January 29, 1948:

I think you are correct in assuming that the figures presented covered all counts, due to the fact that there was no rule limiting the number of colonies on plates to be counted—at least I am of the opinion we were not following such a rule.

It is not clear just when the above rule of reporting was replaced by the present practice of considering as satisfactory only those plates between 30 and 300 (or that nearest 300). Probably many of the steps in the development of our present standards and practises were never recorded. Mr. Abele,[7] in a letter dated December 11,

* "There may have been some cream counts, but the majority of samples were those of retail raw milk." Personal communication from Mr. C. A. Abele dated January 29, 1948.

* See footnote.

1947 to Mr. A. W. Fuchs, recounts these early developmental stages as follows:

> As I recall, it was noted from the laboratory data, that the computed plate counts based upon the colony counts on the two dilution plates sometimes differed considerably, even though the numbers of colonies on both dilution plates fell between 30 and 300. For instance, the count computed from the 1/100 dilution might be 29,000 per ml., and that computed from the 1/1000 dilution might be 70,000 per ml. Both counts on a single sample could not be correct, and the average would be a compromise involving a palpable error.
>
> Mr. Frank, Dr. L. C. Havens, and I considered the matter at some length and eventually concluded that, in the interest of justice to producer and distributor, and to prevent a tendency to select the lower computed count, we would establish for the Alabama laboratories a rule that when both dilution plates were countable (30 to 300 colonies) the higher count would be considered the more accurate, but that the ratio of the two computed counts might not exceed 1:2. Sample results having a higher ratio would be considered unsatisfactory. The ratio of 1:2 was purely arbitrary, but readily attainable with careful technic.
>
> Subsequently, this relatively informal check on the plate count technic was incorporated into the USPHS Milk Code. Under reporting Bacterial Plate Counts (p. 32, 1939 edition) Rule (1) presents a modification of the Alabama rule, in favor of the producer or distributor of the product sampled. The instruction (1) on page 33 is a check on laboratory technic if the records on all samples are available.

A search of literature exposes a complete lack of data on standard plate count ratios which might reasonably be expected to have accumulated over the period of 20 years during which the use of this measure of accuracy has been advocated by the United States Public Health Service. Personal communications to all the state agricultural experiment stations in the United States requesting data or references revealed nothing.

The absence of any reference to this subject is conspicious in a number of instances. Dr. Black, in reporting[1] the survey of laboratories, did not mention plate count ratios but, as previously noted in the Introduction, he did comment on the lack of state supervision. However, the survey form[6] developed and used in this survey, and which has been considered[9] so valuable by the Standard Methods Committee that it has been published for sale by the American Public Health Association, contains the statement on average standard plate count ratios from the *Milk Ordinance and Code* as one of the criteria by which a laboratory is judged.

Although the United States Public Health Service milk shed rating system[10] is a method in general use by many state health departments for measuring compliance with grade requirements of the recommended *Milk Ordinance and Code* for milk and milk products, there is no reference to the average standard plate count ratio, despite the fact that the standard plate count[1] is the method in most general use for determining bacterial counts. A close approach to this subject is made in the "Report Upon Enforcement Methods" with the questions "Is laboratory work done in accordance with latest standard methods?" and "Are records being fully and systematically kept?" However, there is no indication in the discussion of this report that data on count ratios should or must be used in arriving at answers to these questions.

In 1936 the United States Public Health Service conducted[11] a questionnaire survey of "the more important features of the milk supplies and their sanitary control by local authorities in American municipalities of over 1,000 population" and another of general state milk work. Neither of the two questionnaires prepared for and used in these surveys contains any reference to the average standard plate count ratio or to the accuracy of laboratory work being done.

Walker and Randolph,[12] authors of a publication of the Commonwealth Fund devoted to desirable practises in recording the various types of data encountered in routine public health work, discuss the state as the unit basis of a record system and observe that:

> There is a demand for a dispassionate evaluation of services which is possible only if the working records of a health agency are uniform and comparable.

Proportionate space is given to the discussion of milk examination reports and records. Each item considered necessary or desirable is listed for both record and report forms, and specimen forms are given. Average standard plate count ratios receive no recognition and no provision is made for recording them either by the laboratory doing the work or by any state organization functioning in a supervisory capacity.

Experimental Procedure

This study is devoted to an analysis of ratios resulting from the plating of 7,427 samples of raw milk, pasteurized milk, cream, frozen desserts, and chocolate beverage as routinely plated by the Milk and Water Laboratory, Oak Ridge, Tennessee.

In order to secure a basis for comparison it was decided to calculate ratios for a period preceding and for a period following the change to be made in technique. The most practical procedure would have been to use six month periods to correspond with grading periods under the *Milk Ordinance and Code*, but owing to the small percentage of platings of which two dilutions gave counts between 30 and 300, it was thought desirable to use longer periods. It was felt that the results over a longer period would be more significant especially in the case of cream, frozen desserts, and chocolate beverage since the number of samples of these products collected during a six months period would not be large enough to justify being used as a basis for arriving at conclusions. Consequently, average count ratios were calculated over a period of fourteen months beginning January 1, 1945, and extending to February 28, 1946, during which no special attention had been given to count ratios. At the end of this period an effort was made to make each member of the laboratory staff aware of the significance of the clinging drop error. During the months which followed, all members of the staff sought to eliminate this error. The second period for which calculations were made extended from March 1, 1946, to April 30, 1947.

Other changes from previous practises were few. Raw milk samples when received thirty to forty at a time, were plated in groups of ten to fifteen in order to reduce the milk-pipetting to agar-pouring time to 20 minutes. The usual number of pasteurized milk samples during the first period ranged up to twelve as compared with five during the second period. This difference resulted from a change in method of collection over which the laboratory had no control. The methods of spreading agar was changed from rotation on a level table surface to rotation of the plate in the hand with tilting. Since no difference in the uniform distribution of colonies was observed, it is probable that this change had no appreciable effect.

The incubator used for this work was an Elconap B-3 equipped with a water reservoir. During the first period observations indicated that the temperature was, in general, maintained at 35.0° C. to 37.0° C. During the second period, 202 temperature readings were made from thermometers held in stoppered test tubes of water. A reading was recorded each time from the top and bottom shelves. Of the observations made on the top shelf, 42 were above 37.0° C. and none was below 35.0° C., the average being 36.6° C. There were 9 readings above 37.0° C. on the bottom shelf and none below 35.0° C., with an average for this shelf of 36.2° C. The maximum temperature reached was 38.2° C. and the minimum 35.0° C.

The following portions of diluted milk were used for the dilutions plated: 1:10, 1 ml.; 1:100, 1 ml.; 1:1,000, 0.1

ml.; 1:10,000, 1 ml.; and 1:100,000, 0.1 ml. All dilutions used were made using dilution bottles calibrated at 99 ml., pipettes calibrated at both 1 ml. and 1.1 ml., and 11 ml. pipettes. This practise applies to all the dilutions made in the entire study.

DISCUSSION OF RESULTS

The results summarized in Table 1 show the conditions prevailing throughout Period I. The average ratio for the group as a whole was 2.31 and for each product it was above 2.0 with the exception of frozen desserts. Homogenization of ice cream mix resulting in the more uniform distribution of bacteria is apparently the explanation for the low average ratio on frozen desserts. This is further indicated by the fact that ice cream mix produced few ratios, all low, and frozen malt, made from products which had not been subjected to homogenization, gave a high percentage of high ratios. Chocolate beverage gave the highest average ratio but fewer ratios were involved than in the case of any other product.

Table 2 in comparison with Table 1 shows the improvement secured during Period II. The average ratio for this period was 1.85 as compared with 2.31 for Period I. This lowering of the average ratio not only applies to the group as a whole but to the average for each product as well. In addition, the percentage of the number of samples showing ratios is remarkably lower in the case of each product. Pasteurized cream, with an average of 2.15, is the only product which showed an average ratio above 2.0. It appears likely that the poor distribution of bacteria in the large aggregation of fat globules in cream and the resulting physical state when diluted accounts for the high average ratio secured. This product also showed the least reduction in the number of ratios produced with the exception of chocolate beverage which did not show any ratios.

Table 3 is a comparison of the median, minimum, and maximum ratios for Periods I and II. The median ratios for both periods were less than 2.0 on each product with the exception of chocolate beverage which showed a median of 2.73 during Period I and no ratios during Period II. The median ratios on pasteurized milk, raw milk, and on all the products grouped together were reduced during Period II to 1.53, 1.54, and 1.54 respectively, whereas the median values for pasteurized cream and frozen desserts showed a slight increase. However, fewer data were secured on the latter products than on raw and pasteurized milk as shown in Tables 1 and 2. The minimum ratios were highest on pasteurized cream and on frozen desserts during Period I but were reduced slightly during Period II. The highest maximum ratio, 28.64, occurred on pasteurized milk during Period I. All

TABLE 1

AVERAGE STANDARD PLATE COUNT RATIOS OCCURRING DURING THE FOURTEEN MONTH PERIOD OF JANUARY 1, 1945 TO FEBRUARY 28, 1946

No Attention Directed to Avoiding Clinging Drops on Pipette Tips

Product	*Total number of samples plated* *	*Number of samples showing two plates of two different dilutions with counts between 30 and 300*	*Percent of total samples showing two plates of two different dilutions with counts between 30 and 300*	*Average ratio*
Pasteurized milk (Bottled; some bulk)	1,283	163	12.7	2.57
Raw milk (From producers' cans at time of delivery)	1,778	176	9.9	2.16
Pasteurized cream (Bottle; some bulk)	295	29	9.8	2.33
Frozen desserts (Package and bulk)	336	25	7.4	1.85
Chocolate beverage (Bottled)	152	11	7.2	3.27
Total Group	3,844	404	10.5	2.31

* Three dilutions were plated on all samples: 1:10, 1:100, and 1:1,000 on pasteurized products and 1:10, 1:1,000, and 1:10,000 on raw milk (increased to 1:1,000, 1:10,000, and 1:100,000 on 22.2 percent of samples

TABLE 2

AVERAGE STANDARD PLATE COUNT RATIOS OCCURRING DURING THE FOURTEEN MONTH PERIOD OF MARCH 1, 1946 TO APRIL 30, 1947

Measures Taken to Eliminate Clinging Drops on Pipette Tips

Product	*Total number of samples plated* *	*Number of samples showing two plates of two different dilutions with counts between 30 and 300*	*Percent of total samples showing two plates of two different dilutions with counts between 30 and 300*	*Average ratio*
Pasteurized milk (Bottled; some bulk)	558	34	6.1	1.63
Raw milk (From producers' cans at time of delivery)	2,483	102	4.1	1.91
Pasteurized cream (Bottled; some bulk)	97	7	7.2	2.15
Frozen desserts (Package and bulk)	329	11	3.3	1.74
Chocolate beverage (Bottled)	116	0	...	....
Total group	3,583	154	4.3	1.85

* Three dilutions were plated on all samples: 1:10, 1:100, 1:1,000 on pasteurized products, and 1:100, 1:1,000, and 1:10,000 on raw milk. Of the totals above, 23 samples of pasteurized milk, 183 samples of raw milk, 5 samples of cream, and 4 samples of chocolate beverage were plated in duplicate. Each series of plates was tabulated as a separate sample.

TABLE 3

A COMPARISON OF MEDIAN, MINIMUM, AND MAXIMUM RATIOS FOR PERIODS I AND II *

Type of Ratio	*Pasteurized milk*		*Raw milk*		*Pasteurized cream*	
	Period I	*Period II*	*Period I*	*Period II*	*Period I*	*Period II*
Median	1.86	1.53	1.79	1.54	1.81	1.86
Minimum	1.06	1.06	1.00	1.02	1.13	1.08
Maximum	28.64	3.00	16.41	18.02	9.76	3.86
	Frozen desserts		*Chocolate beverage*		*Total group*	
Median	1.51	1.63	2.73	No ratios produced	1.81	1.54
Minimum	1.12	1.08	1.64		1.00	1.02
Maximum	6.70	3.05	5.90		28.64	18.02

* Corresponding to periods comprising Tables 1 and 2 respectively.

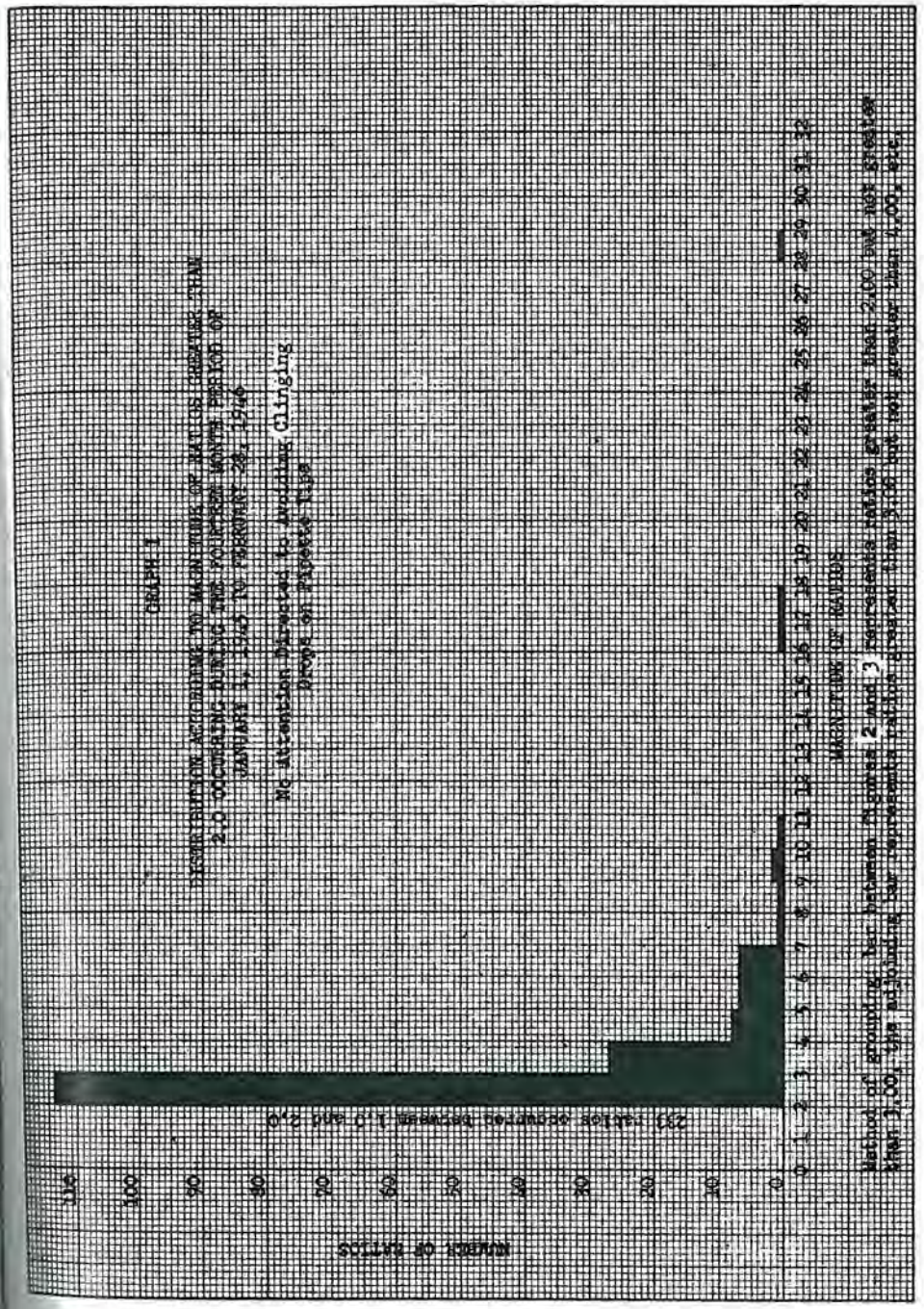
maximum ratios were markedly lower during Period II with the exception of raw milk which showed a slight increase.

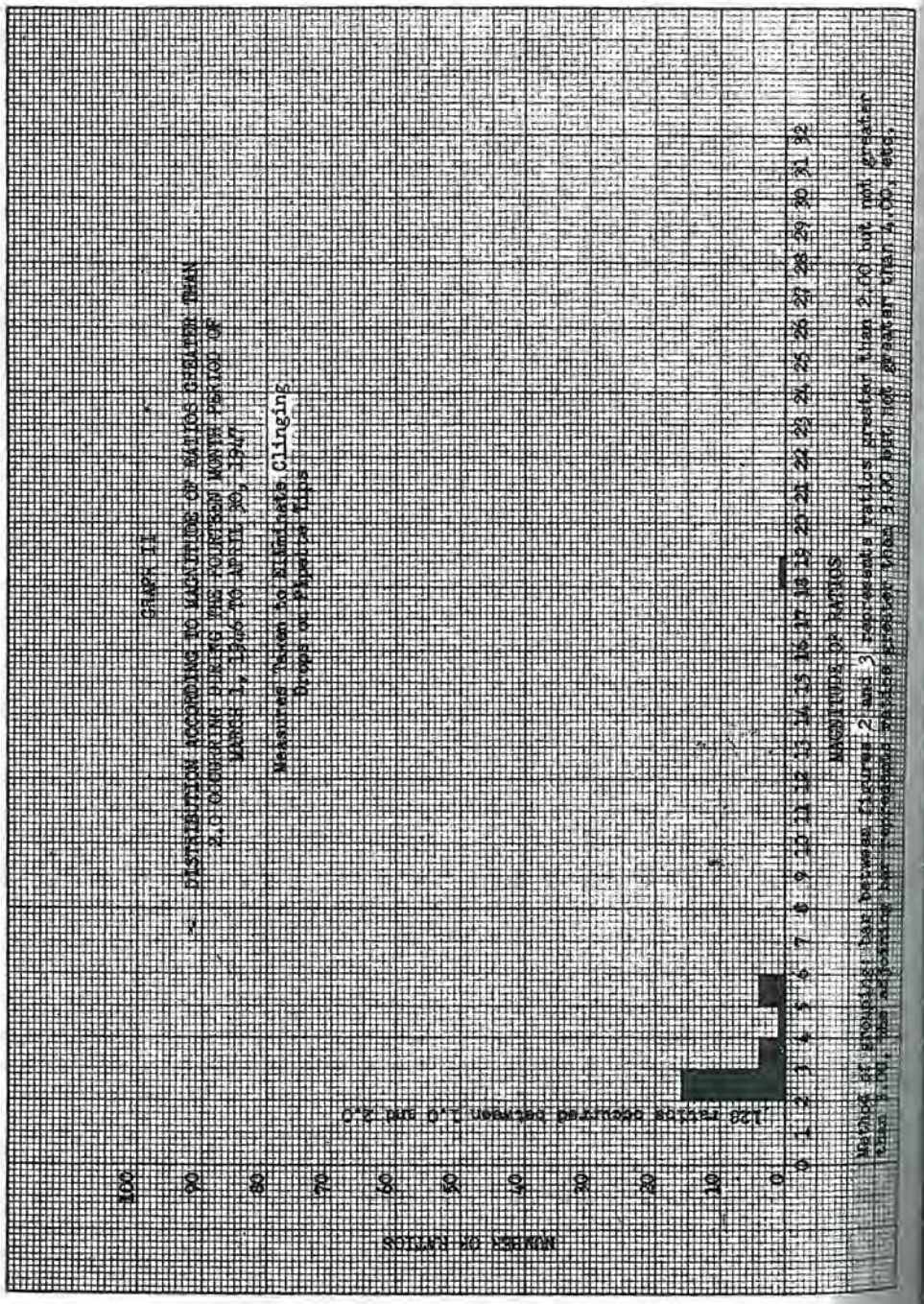
Graph I shows the number of ratios greater than 2.0 occurring during Period I in relation to their magnitude. A comparison with Graph II, which portrays in the same manner the data of Period II, shows a very marked decrease in the number of ratios greater than 2.0. In addition, there is a definite decrease in the magnitude of the resulting ratios. With Group 1, the sharp decline, as the magnitude increases, ends between 10 and 11 (10.23). Of the 404 ratios occurring during this period, 171 were greater than 2.0, of which 168 fell within the general range of distribution indicated above. The three ratios falling beyond this range were 16.41, 17.03, and 28.64. With Group II, the number of ratios is greatly reduced and the general range of distribution ends between 5 and 6 (5.77). Of the 154 ratios obtained, 26 were greater than 2.0, of which 25 conformed to the general range of distribution. The only ratio occurring beyond this range was 18.02.

Summary

The averages of the standard plate count ratios of all samples for which two dilutions gave between 30 and 300 colonies were computed on two groups of standard plate counts made on raw milk, pasteurized milk, pasteurized cream, frozen desserts, and chocolate beverage. It was found that the average ratio was lowered from 2.31 to 1.85 during the course of this study, which brought the average well below the maximum allowable value of 2.0 required by the U.S.P.H.S. Milk Ordinance and Code. The ratios represented by the average of 2.31 were those resulting from the plating of 3,844 samples during a period of fourteen months. The lowered average of 1.85 represents the ratios occurring upon the plating of 3,583 samples during a second period of fourteen months and immediately following the first period. This improvement appears to be largely the result of the attempted reduction to a minimum of drops clinging to the tips of pipettes during the making of transfers for dilution and plating. It is difficult to separate the improvement originating from this source from the influence of at least one other factor. The constant watchfulness required to avoid clinging drops probably resulted in the improvement of other phases of technique without the worker being aware of this tendency.

Four samples of the 7,427 plated gave high ratios which are distinctly separated by an interval from the large number of ratios, 554, conforming to the general distribution according to magnitude as indicated by Graphs I and II. Three of these, 16.41, 17.03, and 28.64, occurred during the first period of fourteen months and one, 18.02, occurred during the second period of fourteen months. That only one of these high ratios occurred during the second period may have been the result of the improved technique or of chance, since there is no way to determine whether these ratios were caused by gross errors in technique or by extremes of bacterial variation. That excessively high ratios may result from the extremes of bacterial variation, as well as from gross errors of technique, seems obvious from the following statement of Brew and Breed [13] regarding errors in duplicate bacteria counts: "In practice, these experimental errors normally range as high as 100 percent to several hundred percent, and occasionally several thousand percent." The basis of the variations considered in this study differs from that on which data on bacterial variations are usually based in that the additional factor of a 1:10 relationship exists between the counts before being multiplied by the dilution factors. Probably most, if not all, such data have been derived from plating





of equal portions of each sample. If this additional factor makes a difference, it seems probable that the variations would be greater.

The rule that average standard plate count ratios of those samples for which two dilutions show between 30 and 300 colonies should not be greater than 2.0 is the equivalent of saying that the average variation of counts computed under the conditions specified shall not exceed 100 percent (variation of the larger from the smaller). During the first fourteen months period, 4.4 percent of the samples plated produced ratios of over 2.0, or varying over 100 percent. During the second period only 0.73 percent varied over 100 percent. This agrees well with the data previously secured by the writer [14] showing that of 299 samples plated in duplicate under very carefully controlled conditions, one percent gave variations of over 100 percent. However, there was a very close approach to having one sample of the 299 produce a variation of 4,445 percent but, owing to certain unsatisfactory features of the count, the rules for reporting [15] made it necessary to report this sample as "laboratory accident." Although this occurred on equal portions of the same dilution, it emphasizes the probability that extreme cases of bacterial variation may also occur between different dilutions producing high ratios which greatly increase the arithmetical average when this value is computed for all the ratios. One such occurrence may result in the average ratio being greater than the allowable maximum of 2.0.

The additional rule [3] that "When the higher plate count is more than twice the lower, record the lower count," tends to safeguard the producer or processor against high counts occurring as the result of either gross errors of technique or extremes of bacterial variation. The laboratory should hold to a minimum the errors of technique but is unable to curb the extremes of bacterial variation.

A tendency was indicated for pasteurized cream to produce high ratios. The poor distribution of bacteria resulting from the high viscosity and high fat content of this product may have been responsible for this tendency.

Frozen desserts made from ice cream mix tended to produce low ratios whereas frozen malt, made from products not subjected to homogenization, gave high ratios and a greater number of ratios. The more uniform distribution of bacteria resulting from homogenization of the ice cream mix apparently explains the differences observed.

The fact that a certain-size portion of a drop deposited with a 1 ml. portion produces an error in measurement only one-tenth as great as when the same addition is made to a 0.1 ml. transfer emphasizes the desirability of excluding 0.1 ml. portions in a scheme of diluting and plating. However, such a procedure would have the added disadvantage of making necessary the use of a greater number of dilution bottles and pipettes, including 11 ml. pipettes.

Conclusions

1. On the basis of fourteen months periods, an average standard plate count ratio of 2.31 was lowered to 1.85 through an organized effort to reduce to a minimum the errors common to pipetting.

2. The carrying over of a drop or portion of a drop on the ends of pipettes during the making of transfers, when technique is such as to permit it, is an error which constantly contributes to the support of a high average ratio.

3. It appears that the average standard plate count ratio can in many cases, but probably not in all, be maintained at a point not greater than 2.0. Although the producer and processor are protected against the extremes of bacterial variation, as well as gross errors of technique, by being given the benefit of the lower count, laboratories

must maintain an average ratio not greater than 2.0 in the face of the greatest variation in bacterial growth or distribution which may occur. It is indicated that, when the errors of technique are held to a minimum, the errors due to bacterial variation, which occasionally reach extremely large proportions, may at times cause average ratios to be greater than 2.0. Additional data are needed to determine the frequency with which this may occur.

4. The setting up of a goal in the laboratory of maintaining an average ratio below 2.0, during each grading period, serves to focus attention on the routine technique employed. Where little attention has been given to clinging drops and the accuracy of pipetting is made the principal point of attack, the tendency is not only toward improvement in this phase of technique but, in addition, it serves to increase the accuracy with which the entire procedure is performed.

5. The ignoring of standard plate count ratios by workers in laboratories, and the failure of administrative officials to use the average as a means of checking on the quality of work being done have undoubtedly resulted in perpetuating high average ratios in many laboratories. Therefore, an opportunity of encouraging accurate technique in the securing of bacterial estimates has been missed.

6. A partial explanation of the failure on the part of laboratory workers and administrative officials to use the standard plate count ratio as a means of judging the quality of laboratory work probably lies in the fact that no reference to it is contained in Standard Methods.

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A SURVEY OF FROZEN PRECOOKED FOODS WITH SPECIAL REFERENCE TO CHICKEN A LA KING

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THIS study was undertaken to determine if potential health hazards exist in frozen precooked foods. These products have been on the market for the past six or seven years and there appears to be no recorded evidence of their implication in outbreaks of food poisoning. Nevertheless, because of the content of some of these frozen precooked foods of ingredients which readily promote bacterial growth, including that of food poisoning pathogens, and because of a scanty literature on the subject, this work was undertaken. The study comprised estimation of the total bacterial flora as determined by the plate count and analysis for the presence, and number if present, of coliform organisms, staphylococci of the food poisoning type, enterococci, (1) and enteric pathogens.

Studies of frozen precooked foods were reported on by Proctor and Phillips. (2, 3) Total plate counts and coliform tests were performed as well as the direct microscopic count. Over one hundred types of such products were examined. It was found that the viable bacterial population varied widely, some foods having counts in excess of 1,000,000 per gram. The categories of products studied were the following: creamed fish, creamed meats, creamed poultry, fish, soups, stews, and miscellaneous. The *average* plate counts for the individual products in each category were usually found to be under 50,000 per gram. The average plate counts exceeded 100,000 in only two of 64 products listed. As concerns *individual* samples, however, four groups of products showed single counts exceeding 100,000. These were 21 samples of creamed fish, of which 9.5 percent exceeded 100,000, the highest count being 154,000; 23 samples of meat products, of which 17.4 percent exceeded 100,000, the highest count being 150,000; and 41 samples of fish, of which 2.1 percent exceeded 100,000, the highest count being 500,000. In a study of coliform plate counts comprising some 500 samples, it was found that the majority of samples of each type of product had coliform counts not exceeding 50 per gram. Samples of fish products, creamed meats, creamed poultry, poultry products, and creamed fish had coliform counts in excess of 100 per gram in 10 to 26 percent of instances, while 10 percent of creamed fish products had counts in excess of 200 per gram, and from 2 to 4 percent of the other categories just mentioned also had counts exceeding 200 per gram.

Fitzgerald (4, 5) has recommended that for most frozen precooked foods, standards for total plate counts of 100,000 per gram and for coliform organisms of 100 per 100 grams be established by manufacturers. He stated that, "These standards appear lenient and should be considered as maximum . . . On the other hand, many products should not be rejected unless counts higher than 500,000 per gram are obtained."

TECHNIC

Procurement of Samples

Samples were obtained from retail and occasionally from wholesale outlets. No set plan was established for obtain-

ing samples or for selecting the type of product sampled other than to attempt to obtain a cross section of the several categories. Chicken a la king was studied regularly after it became evident that this product was, in a sense, a special case.

Examination for Total Plate Count and Coliform Count

Samples were examined on the day they reached the laboratory. The products were allowed to soften until pieces could be broken off by sterile forceps. Eleven grams were then weighed out and placed together with 99 ml. of water in a mechanical disintegrator (Waring or Oster). The machine was spun for 2 minutes, and plates were prepared from the resulting suspension for the total count and the coliform count. Decimal dilutions from 10^{-1} to 10^{-5} were prepared for the total count while the first three dilutions only were used for the coliform count. The media used for the tests were T.G.E.M. Standard Methods agar and Sodium Desoxycholate agar. One ml. of sterile skim milk was added to each plate before it received desoxycholate agar. The total count plates were incubated for two days and the coliform plates were incubated overnight, both at 35° C., before being counted.

Examination for Food Poisoning Type Staphylococci and Enterococci

The technic used for this examination was the same as that described by Dangler and Steffen (6) with the exception that the diluted sample used was the same as that described above and that a test for the ability of enterococci to grow in broth of pH 9.6 was added.

FINDINGS

It became evident early in this study that frozen chicken a la king was yielding bacterial counts in excess of what might have been expected from the reports of Proctor and Phillips. More frequent testing of this product was then instituted and samples were collected over a period of one year. It was noted that two brands only were commonly found on the market. A few samples were obtained of the products of three other processors. The findings relating to the total plate count of frozen chicken a la king are presented in Table 1.

It is noted in the table that more than half of these 39 samples yielded a plate count in excess of 1,000,000 per gram. It is also seen that about 75 percent of the samples of Brand 1 and 40 percent of those of Brand 2 fell in this category.

Coliform testing of frozen chicken a la king revealed that 7.7 percent of all samples yielded counts greater than 100,000 but less than 500,000. Furthermore, 10.3 percent yielded counts greater than 10,000, 18 percent yielded counts greater than 1000, and 38.5 percent yielded counts greater than 100. This is in contrast to the findings of Proctor and Phillips who in the examination of 68 samples of creamed meat and creamed poultry found that only 10.3 percent gave coliform counts in excess of 100 organisms per gram of which 4.4 percent produced counts in excess of 200 per gram. It would thus seem that the coliform counts of this product found by us were much greater than those previously reported for creamed meat and creamed poultry.

It was likewise found that twelve of the 39 samples of frozen chicken a la king yielded staphylococci of the food-poisoning type. Eight of these gave staphylococcus counts between 1000 and 100,000 per gram., two gave counts between 200,000 and 400,000, and one a count of 2,000,000. Nine of the samples yielded enterococci, three of these were under 20,000 per gram, one was 90,000, another 300,000, while four were greater than 1,000,000.

Because of the surprisingly poor bacterial record of this product, as revealed by the above study, a brief survey for comparative purposes was made of chicken a la king prepared and served in restaurants in the city. Twenty samples were obtained from 18 restaurants. These restaurants served food either in the moderate or expensive price range. The findings, as noted in Table 1, are radically different from those with the frozen product. Thus it is observed that no sample yielded a count greater than 100,000, that only one of the samples had a count greater than 10,000, and that only 25 percent (5 samples) yielded counts greater than 1000. This latter figure compares with 97 percent for the frozen product. No coliforms were found in any of the 20 fresh samples and neither were enterococci found, although one sample did yield a count of 1,000 staphylococci of the food poisoning type.*

Samples of other frozen chicken products, such as chicken patties,

TABLE 1

COMPARISON OF PLATE COUNT ESTIMATES OF TOTAL NUMBER OF BACTERIA (35° C.) OF FROZEN CHICKEN A LA KING SOLD AT RETAIL AND WHOLESALE OUTLETS AND FRESHLY PREPARED CHICKEN A LA KING SERVED IN RESTAURANTS

Frozen	Total no. samples	<100	100–999	1,000–9,900	10,000–99,000	100,000–499,000	500,000–990,000	1,000,000 and more
Brand 1	17	0	1	0	1	1	1	13
Brand 2	18	0	0	3	1	5	2	7
Brands 3, 4, 5	4	0	0	0	1	1	1	1
Totals								
Frozen	39	0	1	3	3	7	4	21
Fresh	20	10	5	4	1	0	0	0

	Percent of samples with counts exceeding:					
	100	1,000	10,000	100,000	500,000	1,000,000
Percent Frozen	100	97	90	82	64	54
Percent Fresh	50	25	5	0	0	0

* A brief study was made of the effect of heating frozen chicken a la king prior to consumption on the bacterial flora. Four samples were defrosted at room temperature and heated in double boilers until warm enough to serve. It was found that heating for about eight minutes, which raised the temperature of the product to about 66° C., was sufficient. This moderate degree of heat also destroyed most of the bacteria. Thus initial plate counts of 60,000, 680,000, 8,000,000, and 30,000,000 were reduced to 100, 100, 200, and 2,900 respectively while coliform counts were reduced from 70, 1,800,000, and 1,100,000 to zero in each case. It should be pointed out that although this form of heat treatment is thus apparenly sufficient to destroy enteric pathogens, it would have little if any effect on preformed staphylococcus toxin that might be present.

TABLE 2

PLATE COUNT ESTIMATES OF TOTAL NUMBER OF BACTERIA (35° C.) OF FROZEN CHICKEN PRODUCTS OTHER THAN CHICKEN A LA KING AND COMPARISON WITH MISCELLANEOUS FRESH CHICKEN PRODUCTS

	No. of samples	<100	100–999	1,000–9,900	10,000–99,000	100,000–990,000	1,000,000 or more
	Frozen chicken products other than chicken a la king						
Chicken patties	6	..	..	..	..	3	3
Chicken chow mein	10	..	4	3	2	..	1
Miscellaneous chicken products	5	..	..	..	3	1	1
Totals	21		4	3	5	4	5

	No. of samples	Percent of samples with counts exceeding: 100	1,000	10,000	100,000	1,000,000
Frozen	21	100	81	67	43	24
Miscellaneous fresh chicken products	4	2	..	..	1	1

chicken chow mein, and miscellaneous chicken products, were studied. The findings are given in Table 2. It is noted that 67 percent of these 21 poultry samples had counts in excess of 10,000. This is less than the figure of 77 percent recorded by Proctor and Phillips for 26 samples of miscellaneous chicken products. On the other hand, these authors found no counts exceeding 100,000, whereas in this study 43 percent exceeded 100,000 and 24 percent exceeded 1,000,000. Although only four samples of fresh chicken products were obtained from restaurants; the highest total count found among these was only 24,000.

products. Thus 33 percent exceeded a total count of 10,000 whereas 67 percent of other chicken products and 90 percent of chicken a la king exceeded this count. However, 19 percent of the samples did exceed a count of 100,000 and 7 percent did exceed one of 1,000,000. Five only of these 51 samples yielded coliforms. Four were under 100 per gram and the remaining one was 7,700. Only three of the products yielded staphylococci of the food-poisoning type. The counts of staphylococci were 46,000, 120,000, and 370,000. None of these products yielded enterococci.

All the frozen foods examined in this

TABLE 3

PLATE COUNT ESTIMATES OF TOTAL NUMBER OF BACTERIA (35° C.) OF OTHER FROZEN PRECOOKED PRODUCTS

	No. of samples	<100	100–999	1,000–9,900	10,000–99,000	100,000–499,000	500,000–990,000	1,000,000 or more
Creamed meat products	2	1	..	..	1	..	..	..
Creamed fish products	9	..	..	4	2	1	..	2
Other meat products	21	5	7	4	2	1	..	1
Other fish products	9	2	1	3	..	2	..	1
Soup products	4	1	2	1	..	..	..	..
Miscellaneous products	7	1	..	3	2	1	..	..
Totals	52	10	10	15	7	5	1	4

Percent of samples with counts exceeding:

100	1,000	10,000	100,000	500,000	1,000,000
81	62	33	19	10	7

Six of the 21 frozen chicken products yielded coliform counts of which two were less than and four greater than 100 per gram. Three of the latter exceeded 1,000 per gram. No staphylococci nor enterococci were found. The four fresh chicken products yielded neither coliforms, enterococci, nor staphylococci.

The findings with the other frozen precooked products are given in Table 3. The counts, on the whole, were markedly superior to those with chicken a la king and with the other chicken

study were also tested for the presence of enteric pathogens. In no instance were such organisms found.

DISCUSSION

The great discrepancy between the bacterial findings on frozen chicken a la king and freshly prepared chicken a la king as served in restaurants is surprising. The presence of coliforms could have been expected with such high total counts in the frozen products but the finding of staphylococci of the food-poisoning type and enterococci

was not necessarily to be expected. Fitzgerald, however, did state in a discussion of the possible occurrence of staphylococcus food poisoning as a result of the ingestion of frozen precooked foods that, "such (foods) as chicken a la king may potentially be sources of staphylococcus food poisoning. One can easily visualize the contamination which may take place in hand-picking poultry meat from cooked chicken. One can also visualize the difficulty of sterilizing such meat without re-cooking. A person having a boil or other festered sore, or a cold or other similar infection, might cause the contamination, since toxigenic staphylococci may be present. When such highly contaminated meat is combined with starch, milk, or egg-thickened cream sauce and frozen it is quite impossible to avoid the resulting bacteriological contamination no matter how careful, clean, or well regulated the operation may be otherwise. Spoilage of such a product at room temperature would probably be necessary to cause sickness, however, because Lockhead and Jones (6) indicated the toxin cannot be elaborated while the food is refrigerated." Fitgerald also stated that "The enterococci and other gastrointestinal bacilli may or may not be implicated in food infection from frozen foods since direct evidence appears to be lacking. However, the protection of spoilage usually associated with food intoxications does not apply against infections, and extreme precautions against contamination are necessary."

If, as seems most likely, contamination with staphylococci and perhaps even enterococci occurs before freezing, the relatively small degree of heating of the frozen product prior to serving, while probably sufficient to destroy the great majority of microorganisms, will give little protection against the possible thermostabile toxic effect (staphylococci). Certainly, it would appear that, apart from intrinsic objections to an unclean operation, lack of care by the person preparing the meal, such as allowing the de-frosted food to remain at temperatures conducive to bacterial growth, would constitute a very definite health hazard. It seems reasonable, therefore, to demand that this frozen product yield a much smaller bacterial flora than was found in the present study. Since counts diminish during storage in the frozen state (Proctor and Phillips), (2) it seems most likely that contamination occurs prior to freezing, and that the problem is one of sanitation which must be solved by manufacturers in their own plants. The establishment of bacteriological, as well as other standards if necessary, by enforcement agencies might be the needed stimulant.

The samples of the other products studied were relatively too few in number to allow any final conclusions to be drawn. It is noticed, nevertheless, that the bacteriological status of chicken patties and miscellaneous chicken products, but not chicken chow mein, is such as to raise doubts as to their sanitary quality. Likewise, the record of the other frozen precooked products appears, on the whole, to be satisfactory but the fact that 8 of 52 (7 percent) of the samples had counts greater than one million per gram should not be conducive to the complete peace of mind of the enforcement officer.

SUMMARY

A survey of the bacteriological status of a limited number of frozen precooked foods was made.

It was found that chicken a la king yielded total plate counts and coliform counts which were higher than reasonable standards would allow. A similar judgment would also apply to the finding of staphylococci of the food-poisoning type and enterococci, each in about one fourth of the chicken a la king samples examined.

Most but not all of the other frozen precooked products sampled were by comparison of a superior sanitary status. The total number of these sam-

(Continued on page 231)

INACTIVATION OF BACTERIOPHAGE OF THE LACTIC ACID STREPTOCOCCI OF STARTERS BY QUATERNARY AMMONIUM COMPOUNDS *

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In recent years, numerous investigators, particularly in New Zealand, Australia, England, Canada, and the United States, have reported on the problems and economic aspects of "slow starter" in relation to the cheese industry. These investigations have pointed to bacteriophage infection of the lactic acid streptococci starter organisms as the most important cause of this condition.

A thorough cleaning and bactericidal treatment of cheese plant equipment are among the necessary procedures for the prevention and control of an outbreak of bacteriophage. A number of workers [1, 2, 5, 8, 9] have reported on the methods of application and effectiveness of hypochlorite solutions for this purpose.

During recent years the quaternary ammonium compounds have come into use as sanitizing agents in food processing and manufacturing establishments. For dairy plant equipment the usually recommended concentration is 200 p.p.m. No data, however, have been presented on the effectiveness of these substances as inactivators of bacteriophage of the lactic acid streptococci of cheese starters. The data presented in this report represent observations carried on under laboratory conditions using several different types of quaternary ammonium compounds and several strains of bacteriophage.

Klein *et al.*[4] observed that bacteriophages differ in their resistance to the direct action of synthetic detergents. Bacteriophage strains for *Shigella paradysenteriae* and *Staphylococcus albus* were inactivated by cationic detergents in high dilutions, whereas a strain of *Escherichia coli* bacteriophage was resistant to high concentrations of these reagents. Kalter *et al.*[3] exposed diluted sewage to the action of a cationic detergent and by this method were able to isolate coliform bacteriophage races without the usual filtering technique. Their study was not designed to test the effectiveness of the cationic detergents in the destruction of bacteriophage. It did show that this lytic agent is more resistant than its host culture to these substances.

Materials

The quaternary ammonium compounds used in this study were commercial preparations of 10 to 13 per cent concentrations. The active ingredients were as follows: Alkyl (C_8H_{17}–$C_{18}H_{37}$) di-methyl benzyl ammonium chloride; di-isopropyl phenoxy ethyl di-methyl benzyl ammonium chloride; di-isobutyl phenoxy ethoxy ethyl dimethyl benzyl ammonium chloride; lauryl di-methyl benzyl ammonium chloride; 9 octa-decenyl di-methyl ethyl ammonium bromide; and N(acyl colamino formyl methyl) pyridium chloride.

The bacteriophage filtrates were prepared as described by Wagenaar and Prouty.[7] Freshly prepared filtrates of high bacteriophage titer were on hand for each trial throughout the study.

Procedure

Dilutions, ranging from 200 to 5 p.p.m., of the quaternary ammonium compounds were prepared in 100 ml. amounts using sterile distilled water and 6 oz. screw cap bottles. One water blank, with no added quaternary, was included with each series to serve as a control.

A stock flask of sterile skim milk containing resazurin indicator in the usual amount was seeded with a 1.0 per cent inoculum of the test culture. Ten milliliter portions of this freshly prepared culture were dispensed aseptically into each of as many sterile plugged tubes as were required for the determination.

One-tenth milliliter portions of the bacteriophage filtrate were added, at properly spaced intervals, to each of the dilutions of the quaternary ammonium compounds under test and the water control, followed immediately by a thorough mixing of the contents.

At intervals of 2 minutes, continuing over a period of 20 minutes, 0.1 ml. portions of the mixture from each test dilution were transferred to tubes containing 10 ml. of the inoculated skim milk as prepared above with the homologous host culture. The determination was carried out at a temperature of 20 to 22° C. Each tube was inverted once, after the cotton plug had been replaced, to obtain a thorough mixing. Control tubes to check the culture and the potency of the bacteriophage filtrate were included in each determination. Incubation was carried out at 30° C.

The use of resazurin in the milk cultures materially assisted in following the activity of the cultures as indicated by the color changes. Cultures in which the bacteriophage had been inactivated by the test quaternary compound progressed rapidly from mauve to pink, to white. In the presence of active bacteriophage the color change usually would not progress beyond the pink stage and when this did occur it would invariably revert to the pink stage as the incubation continued.

The presence of acid coagulation together with the resazurin color changes as compared with corresponding reactions of the control tubes were used to indicate the presence or absence of active bacteriophage.

Results

A summary of the results secured with each quaternary ammonium compound are presented in Tables 1 to 6.

Table 1. *Alkyl di-methyl benzyl ammonium chloride.* Inactivation of the bacteriophage occurred in all seventeen trials after 2 minutes of exposure using a concentration of 200 p.p.m. With 100 and 80 p.p.m., inactivation was complete in 16 of the trials at the 2- and 4-minute periods and was complete in all at the 6-minute period. When concentrations of 40 and 20 p.p.m. were

TABLE 1

Inactivation of Lactic Acid Streptococci Bacteriophage by Alkyl Di-methyl Benzyl Ammonium Chloride

Summary of 17 Trials

(Figures indicate numbers inactivated)

Minutes of Exposure	*Concentration: parts per million*							
	200	*100*	*80*	*40*	*20*	*10*	*5*	*Control*
2	17	16	16	11	10	4	0	0
4	17	16	16	14	11	13	3	0
6	17	17	17	14	10	13	6	0
8	17	17	17	17	13	14	9	0
10	17	17	17	17	15	13	12	0
12	17	17	17	16	14	14	12	0
14	17	17	17	16	14	14	12	0
16	17	17	17	16	14	14	12	0
18	17	17	17	16	15	15	12	0
20	17	17	17	16	15	15	12	0

* Published as Scientific Paper No. 818, College of Agriculture and Agricultural Experiment Station, Institute of Agricultural Sciences, State College of Washington, Pullman.

TABLE 2

INACTIVATION OF LACTIC ACID STREPTOCOCCI BACTERIOPHAGE BY DI-ISOPHROPYL PHENOXY ETHOXY ETHYL DI-METHYL BENZYL AMMONIUM CHLORIDE

SUMMARY OF 14 TRIALS

Minutes of Exposure	*Concentration: parts per million*							
	200	*100*	*80*	*40*	*20*	*10*	*5*	*Control*
2	14	14	14	12	6	0	0	0
4	14	14	14	12	6	2	0	0
6	14	14	14	14	8	4	0	0
8	14	14	14	12	10	4	0	0
10	14	14	14	12	12	4	2	0
12	14	14	14	12	12	4	2	0
14	14	14	14	12	10	4	2	0
16	14	14	14	14	10	4	2	0
18	14	14	14	12	12	4	2	0
20	14	14	14	12	12	4	2	0

used, inactivation occurred in most of the trials after 2 minutes of exposure. However, at these concentrations, 20 minutes of exposure did not affect inactivation in all of the test trials. Concentrations of 10 and 5 p.p.m., particularly at the longer periods of exposure, resulted in inactivation in the majority of trials.

Table 2. *Di-isopropyl phenoxy ethoxy ethyl di-methyl benzyl ammonium chloride.* Concentrations of 200, 100, and 80 p.p.m. resulted in inactivation of the bacteriophage after 2 minutes of exposure in all fourteen trials. A concentration of 40 p.p.m. effected inactivation in the majority of the trials at the 2-minute period of exposure, but inactivation did not occur in all trials even after 20 minutes of contact with the test solution. Inactivation occurred in most but not all of the trials after 6 to 10 minutes of exposure when a concentration of 20 p.p.m. was used. Ten and 5 p.p.m. concentrations resulted in destruction of the bacteriophage in only a few of the trials even after exposure periods of 20 minutes.

Table 3. *Di-isobutyl phenoxy ethoxy ethyl di-methyl benzyl ammonium chloride.* Inactivation of the bacteriophage was complete in all ten test trials after 2 minutes of contact with concentrations of 200 and 100 p.p.m. With 80 and 40 p.p.m., inactivation was complete in all trials after 8 and 10 minutes of exposure respectively. Twenty, 10, and 5 p.p.m. concentrations failed to bring about inactivation in all trials after 20 minutes of contact.

TABLE 3

INACTIVATION OF LACTIC ACID STREPTOCOCCI BACTERIOPHAGE BY DI-ISOBUTYL PHENOXY ETHOXY ETHYL DI-METHYL BENZYL AMMONIUM CHLORIDE

SUMMARY OF 10 TRIALS

Minutes of Exposure	*Concentration: parts per million*							
	200	*100*	*80*	*40*	*20*	*10*	*5*	*Control*
2	10	10	8	8	4	0	0	0
4	10	10	10	8	5	2	0	0
6	10	10	8	8	8	3	0	0
8	10	10	10	8	8	4	0	0
10	10	10	10	10	8	6	1	0
12	10	10	10	10	8	6	2	0
14	10	10	10	10	8	6	2	0
16	10	10	10	10	9	6	4	0
18	10	10	10	10	8	6	4	0
20	10	10	10	10	8	6	4	0

TABLE 4

INACTIVATION OF LACTIC ACID STREPTOCOCCI BACTERIOPHAGE BY LAURYL DI-METHYL BENZYL AMMONIUM CHLORIDE

SUMMARY OF 14 TRIALS

Minutes of Exposure	*Concentration: parts per million*							
	200	*100*	*80*	*40*	*20*	*10*	*5*	*Control*
2	14	14	12	12	10	10	6	0
4	14	14	14	12	11	10	8	0
6	14	14	12	12	11	10	10	0
8	14	14	14	14	11	11	10	0
10	14	14	14	14	12	12	10	0
12	14	14	14	14	14	14	12	0
14	14	14	14	14	14	14	12	0
16	14	14	14	14	14	14	12	0
18	14	14	14	14	14	14	12	0
20	14	14	14	14	14	14	12	0

Table 4. *Lauryl di-methyl benzyl ammonium chloride.* Concentrations of 200 and 100 p.p.m. resulted in inactivation in all fourteen trials after 2 minutes of exposure. Inactivation was not complete, in all trials, in concentrations of 80 and 40 p.p.m. until after 8 minutes of exposure. Twenty and 10 p.p.m. concentrations gave inactivation in all trials after 12 minutes. At a concentration of 5 p.p.m., inactivation occurred in the majority of the trials after 4 minutes of exposure. However, at no exposure period did this concentration effect inactivation in all trials.

Table 5. *9 octa-decenyl di-methyl ethyl ammonium chloride.* Concentrations of 200, 100, and 80 p.p.m. resulted in inactivation in all nine trials after 2 minutes of exposure. Concentrations of 40, 20, and 10 p.p.m. effected similar results after 6 minutes of exposure. At 5 p.p.m. the majority, but not all of the trials, showed inactivation after 6 minutes of exposure.

Table 6. *N(acyl colamino formyl methyl) pyridium chloride.* Concentrations of 200 and 100 p.p.m. effected inactivation in all sixteen trials after 2 minutes of exposure. At a concentration of 80 p.p.m., an exposure of 8 minutes was necessary for inactivation in all trials. Concentrations of 40 and 20 p.p.m. resulted in inactivation in the majority, but not all, of the trials after 6 and 12 minutes of exposure respectively. The inactivation rate with a concentration of 10 p.p.m. was of the minority order and no inactivation occurred with 5 p.p.m. at any time period.

TABLE 5

INACTIVATION OF LACTIC ACID STREPTOCOCCI BACTERIOPHAGE BY 9 OCTA-DECENYL DI-METHYL ETHYL AMMONIUM BROMIDE

SUMMARY OF 9 TRIALS

Minutes of Exposure	*Concentration: parts per million*							
	200	*100*	*80*	*40*	*20*	*10*	*5*	*Control*
2	9	0	9	3	3	4	2	0
4	9	9	9	6	6	5	2	0
6	9	9	9	9	9	9	5	0
8	9	9	9	9	9	9	5	0
10	9	9	9	9	9	9	6	0
12	9	9	9	9	9	9	7	0
14	9	9	9	9	9	9	7	0
16	9	9	9	9	9	9	7	0
18	9	9	9	9	9	9	7	0
20	9	9	9	9	9	9	7	0

Discussion

Some variations in the effectiveness of the quaternary ammonium compounds used in this study for the inactivation of bacteriophage are evident. All, however, were effective agents. Alkyl di-methyl benzyl ammonium chloride was the only one that did not inactivate the bacteriophage in all trials in a concentration of 100 p.p.m. at the 2 and 4 minutes exposure periods. On the other hand the degree of inactivation with this compound at the lower concentrations was greater than was that of several of the others used. N(acyl colamino formyl methyl) pyridium chloride was the least effective in the low concentrations.

TABLE 6

Inactivation of Lactic Acid Streptococci Bacteriophage by N(Acyl Colamino Formyl Methyl) Pyridium Chloride

Summary of 16 Trials

Minutes of Exposure	*Concentration: parts per million*							
	200	*100*	*80*	*40*	*20*	*10*	*5*	*Control*
2	16	16	14	3	4	0	0	0
4	16	16	14	6	6	2	0	0
6	16	16	15	10	7	2	0	0
8	16	16	16	13	8	2	0	0
10	16	16	16	14	8	4	0	0
12	16	16	16	14	10	4	0	0
14	16	16	16	14	10	4	0	0
16	16	16	16	14	10	6	0	0
18	16	16	16	14	10	6	0	0
20	16	16	16	14	10	0	0	0

The bacteriophage concentrations used in this study undoubtedly were many times greater than would be found on adequately cleaned cheese plant equipment. Some of the filtrates were of a titer of 10^{-10} power. Transfer of such a filtrate to the quaternary test solution resulted in a bacteriophage concentration of 10,000,000 particles per milliliter.

In the use of a chlorine solution as a sanitizing agent in dairy plants, the United States Public Health Service[6] recommends a minimum exposure period of 2 minutes. Based on the results secured in this study, using a relatively high bacteriophage population, the exposure of cheese plant equipment to a 200 p.p.m. concentration of a quaternary ammonium compound for a period of 2 minutes would appear to be adequate and would offer a margin of safety in the destruction of bacteriophage of the lactic acid streptococci of cheese starters.

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THE MILK COOLING PROBLEM*

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Even though the temperature outside is well below freezing this does not solve our milk cooling problem. The proper cooling of milk is a problem that confronts us every day and is not just a seasonable one. It may be true that improper cooling has a more marked effect in warm weather, but proper cooling is just as important today as it will be six months from now when we are sweltering in that August heat.

Quality milk is that which is safe—being low in bacteria count; that which is clean—free from dirt and organic matter; and that which is free from objectionable odors and flavors.

I like to group all the steps to produce this quality milk into three major ones as follows: *first,* disease-free dairy cows; *second,* prevention of contamination from external sources—mainly unsanitary and improper handling; and *third,* preservation of this quality by proper cooling.

Cooling Requirements

I cannot emphasize too strongly that proper cooling will by no means offset carelessness in production and handling. The farmer must ever strive to maintain the health of his dairy herd, and the best possible sanitary handling practises. The same attention, or even more attention, should be given to sanitation when proper cooling methods are to be followed. It should be understood by all, that cooling milk does not *improve* quality but merely tends to maintain its *initial* quality. It is true that some of the careless farmers have been able to reduce their bacteria count by installing mechanical cooling. This reduction in bacteria count may give the impression that this careless farmer is producing quality milk, but if his milk were to be subjected to a sediment test, it would prove that he was meeting only the bacterial count requirement for quality milk and not the others.

I need not remind you Dairy Fieldmen that milk is highly perishable because of its composition. Bacteria thrive to an amazing degree in milk, and are for the most part responsible for its souring or decomposition. Proper cooling is the chief factor in preventing the growth of these bacteria in milk. For example, the United States Department of Agriculture reports in their Farmers' Bulletin No. 1818 that milk with a bacteria content of 16,000/ml. kept sweet for about *36 hours* when held at *75° F.; 80 hours* when held at *55° F.;* and *180 hours* when held at *40° F.* This shows that properly cooled milk will stay sweet approximately *five* times longer than milk held at ordinary room temperatures.

Let us discuss briefly what we mean by proper cooling. Proper cooling may be considered any cooling that meets the cooling requirements of the Public Health Service Milk Ordinance for the grade of milk being produced. Cooling requirements for Grade A milk in the current milk ordinance of the United States Public Health Service reads as follows: "Milk must be cooled immediately after completion of milking to 50° F. or less and maintained at that average temperature as defined in 1 (S) until delivery." Some local regulations require that it be cooled to 40° F. instead of 50° F. These regulations are modified somewhat if milk is to be delivered to a

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plant for pasteurization within 2 hours after milking.

METHOD OF COOLING

Now that we are well aware of the reasons for cooling milk, and the cooling requirements to preserve the quality of milk, let's look at the methods of cooling that may be used on farms.

1. Cold air
2. Well or spring water
3. Ice
4. Mechanical refrigeration

Before we can decide on the relative merits of any cooling method we must know how much heat must be removed and the rate of heat transfer through the cooling medium.

One gallon of 4 percent milk weighs 8.6 pounds. The specific heat is 0.93. Thus, $8.6 \times 0.93 = 7.998$ or, for all practical purposes, 8 BTU must be removed from each gallon of milk for each degree the temperature is lowered.

As for the rate of heat transfer it will be well to remember that under ordinary conditions *water* is over *21 times* as efficient for cooling as is *air* AT THE SAME TEMPERATURE.

First, the cold air method. Milk in bulk cannot be air-cooled rapidly enough to meet the requirements of any Public Health Service Milk Ordinance. Studies made at the Agricultural Experiment Station of Kansas State College of Agricture show that milk in 10-gallon cans at 95° F. placed in a dry box cooler held at 41° F. and equipped with a 12-inch circulating fan inside the box was at an average temperature of 58° F. after eight hours in the cooler. The milk in the very tip of the can was still above 70° F. Nicholas of Pennsylvania State College states that at the end of two hours separation of the cream in a can of freshly cooled milk is practically complete, and as much as 99 percent of the contained organisms may have been filtered into the cream layer which is, of course, the last area to cool. These two outstanding facts show that cold air is totally inadequate for the proper cooling of milk in bulk. It is used to good advantage, however, in the storing of pre-cooled milk.

Second, well or spring water. It is the mistaken opinion among some farmers that placing a 10-gallon can of milk in a half-barrel of well water with a wet cloth wrapped around the top of the can will provide proper cooling. Cold water is one of the cheapest methods of cooling milk on the farm, and probably the most widely used. The effectiveness of well-water cooling depends upon the temperature of the water and the methods of handling the milk. The well water should not have a temperature higher than 50° F. to provide proper cooling. Well-water temperatures in the LaCrosse area are generally above 50° F., and water cannot be considered an effective method of cooling for this area.

If a farmer does have a source of water with a temperature of 50° F. or lower, he can satisfactorily cool milk if he closely follows a few simple rules. These rules are:

1. Be certain that the temperature of the water does not increase to any extent between the source of supply and the cooler.
2. Use an insulated tank of proper design and construction, plans for which can be obtained from the University of Wisconsin or the United States Department of Agriculture.
3. Maintain a water-to-milk ratio of 3:1 in the tank, and run enough well water through the tank to give a water-to-milk ratio of 11:1 as recommended by Nicholas of Pennsylvania State College.
4. Where milk is to be stored in a well-water cooler, as in the case of night milk held until delivery time the next morning, enough fresh water must be run through the tank after the milk is cooled to maintain the milk at constant temperature.

This method of cooling requires much more water than most people realize. To propertly cool four 10-gallon cans of milk within the prescribed time limit would require 440 gallons of well water at 50° or lower. This creates quite a problem where water supplies may become limited during the summer months and where drainage imposes a major problem in disposing of the overflow water from the cooler. Even with these disadvantages, cooling with well water is and will continue to be for some years to come, the most common method of milk cooling. All of us should continue to strive to help the farmer do a better job with this method until the wheels of progress bring us to a point where a better and more efficient method is adopted by most farmers.

Third ice. Ice will, of course, give proper cooling of milk in cans if enough ice is used at the start and more is added soon enough to maintain a water temperature at a proper degree to insure quick cooling and a safe storage of milk. The water temperature should be at least down to 40° F. to provide rapid cooling and enough ice added during the cooling period to maintain this temperature. It requires approximately 20 pounds of ice to absorb enough heat from 10 gallons of milk to lower its temperature from 90° F. to 50° F.

In order to cool this amount of milk rapidly enough, and to take care of heat transfer losses, it will actually require from 30 to 40 pounds of ice to cool properly this 10-gallon can of milk. The average cost of ice reported by most surveys is 30¢ per 100 pounds. It might be somewhat higher at prices today. We can very readily conclude that ice provides a means of properly cooling milk far better than any discussed so far; yet it is expensive, messy, not always reliable, and requires more work and attention than other methods.

Fourth, mechanical cooling. This is the most efficient method being used today. This type of cooling has shown a very rapid increase in recent years chiefly because of: (1) improvements in machines; (2) extension of electrical lines and reduced cost of electricity; (3) irregularity of deliveries of ice; (4) saving in labor and advantages of automatic operation; and (5) regulations of health departments. An interesting note in regard to health regulations is the fact that the Manitowoc milk market has required mechanical cooling for a period of more than eight years.

With their many advantages, mechanical coolers are still used only on a small percentage of the 177,745 farms in Wisconsin.

A farmer may increase his cash returns by using a mechanical cooler in two ways. First, by reducing the amount of milk rejected or lost due to spoilage; and second, by receiving bonus payments paid by some markets for higher grades and properly cooled milk.

TYPES OF MECHANICAL COOLERS

Mechanical coolers are divided into two general types, the wet box and the dry box.

Wet Box

The wet box consists of an insulated tank filled to the proper level with water. This water bath is maintained at a temperature of 36° to 40° F. by means of cooling coils and a refrigating unit. Milk to be cooled is placed in cans—usually 10-gallon cans—which in turn are placed in this refrigerated water bath and remain there until time for delivery to the milk plant. This method is a simple, efficient, and inexpensive one for producers selling milk in bulk to milk plants. It is therefore generally used by the average dairy farmer and producer using mechanical cooling.

Points, other than cost, that a farmer should consider when purchasing a wet box type of cooler are:

1. *Construction.* The general construction should meet many rigid requirements, as follows: Should be correctly proportioned, so as

to hold the correct amount of waters; should be properly insulated; should be water tight and relatively air tight, and must be rust-proof. The refrigeration coils should be the correct size and number for the particular size box, and the compressor unit should be engineered to the job of cooling; should be matched size for size with the cooling coils and cabinet in order to have a balanced unit. Having a balanced unit cuts down operating cost. The unit should be equipped with automatic switches and overload devices and should have some provisions for agitating the water. Agitators may be either of the mechanical pump or penumatic type. Both work very successfully and will reduce the cooling time approximately by one half. The farmer usually must rely on the reliability of the manufacturer for construction features.

2. *Size.* The wet box types of cooler frequently known as an immersion cooler, is made in sizes ranging from a two-can that will cool four 10-gallon cans of milk per day, to a 20-can that will cool 40 cans every 24 hours. Certainly most of the farmers can find one of these sizes to fit his needs. In considering size, the amount of milk produced at peak production is the determining factor. It is also wise to consider any increase in production that might occur. It is better and more economical to take care of this probable increase in production in the initial installation.
3. *Installation.* The problem of installation includes many factors such as proper location, design of milkhouse, wiring, water inlets and outlets, drainage, sanitation, and many others. I recommend that farmers seek the advice and publications of the agricultural colleges and Public Health Service on matters of proper installation.

For convenience, and to save personal wear and tear, this type of cooler should set down in the floor. A study to determine the correct or best height of installation is currently being set up at our Electric Research Farm. Hoists for lifting cans in and out of coolers are also available.

This type of cooler has one decided advantage that I like very much. It eliminates the need for an aerator or surface cooler, which is one source of contamination. Aerators are difficult to clean properly, and most farmers are apt to neglect them. It is true that a surface cooler will increase the capacity of the wet box, but I prefer that they not be used, for sanitary reasons.

Dry Box

The dry box type of cooler may be classified according to the way in which the refrigerating effect is produced in the cold box as follows: (1) By the brine system; and (2) direct expansion system. The direct expansion system is generally the more efficient of the two, but lacks capacity. Therefore, it is not too widely used for this work. The type of dry box storage is very popular among retail dairymen for storing milk in bottles.

An aerator or surface cooler must be used to rapidly cool milk before it is placed in a dry box cooler. We have already discussed the rate of cooling with cold air and know that is too slow to meet the requirements.

I do not necessarily recommend all or any of the following practices, but let us see what a farmer can do to cool his milk adequately.

1. Cool with ice, or 50° F. well or spring water, following the rules outlined earlier.
2. Run enough 50° F. water through a properly constructed tank in order to cool the milk down some 20° to 30° F. and remove the balance with a "drop-in" type compressor unit. In this case the water-to-milk ratio should be as low as possible so that when the water is turned off and the compressor is started manually it will have to cool only a small amount of water. A farmer could use a smaller compressor, and operate it fewer hours per day to cool his milk this way, but it would require careful attention and timing, and could not be made to operate automatically.
3. He could construct his own properly insulated tank and install a "drop-in" type compressor unit. The compressor unit only, for a six-can cooler costs about $245 as compared to $391 for the complete unit. Surely the farmer can build a good tank for less than $146. The United States Department of Agriculture found that homemade tanks were as efficient as manufactured tanks; however, they all had 1-inch more insulation than the commercial tanks.
4. He can purchase a complete mechanical cooler.

Summary

Now to sum up the facts and make some recommendations:

1. Cold air is totally inadequate for cooling milk, but is excellent for storing milk that has already been cooled by other means.
2. Well or spring water should be 50° F. or less to be considered worth while for cooling milk. Large quantities of agitated water must be used before effective cooling can be obtained. Pennsylvania State College recommends as high as 11:1 water-to-milk ratio. An insulated cooling tank with 3 inches or more of insulation should be used.
3. Ice will provide proper cooling, but is messy, requires more work, and is unreliable. Even with ice at 30¢ per hundred pounds, it will cost about 11¢ to cool one can of milk with ice, as compared to about 5 to 7¢ per can or less with electricity—depending on how the milk is handled. This is figuring electritcy at 2¢ per kilowatt hour, depreciation at 10%, interest at 7%, and repairs at 3% per annum.
4. Mechanical refrigeration is the most efficient and economic means of accomplishing this cooling if equipment of proper size and type is used.
5. Wet box coolers eliminate the use of an aerator or so-called surface cooler and use less current than most other methods. The average consumption is approximately 1 kw-hr. per 100 pounds of milk cooler below 50° F.
6. Stirring of milk during cooling will slightly speed up the rate of cooling, but introduces another source of contamination and should not be recommended.

It is apparent, after weighing all the facts, that the *wet box cooler* employing an ice bank for the most rapid cooling and equipped with some means of agitating the water during the first hour of operation, is the one piece of cooling equipment that meets the requirement of most wholesale milk producers today.

FACTORS TO BE CONSIDERED IN TESTING QUATERNARY AMMONIUM COMPOUNDS *

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INTRODUCTION

WITHIN the last ten years certain members of a group of chemicals known as quaternary ammonium compounds have been suggested for the sterilization of equipment. These differ in several respects from other types of disinfectants, and much experimental work has been reported concerning their properties and reported effectiveness. Considerable differences of opinion exist regarding the relative bactericidal efficiency of these newer materials, much of which may be attributed to the choice of methods used in estimating their bacteriostatic or bactericidal properties.

In view of the general interest of sanitarians in application of these newer chemical agents, and particularly because of the conflicting results to be found in the literature, it seems pertinent to review briefly some of the factors to be considered in testing quaternaries and related sanitizing agents. Although many sanitarians are not in a position to test such compounds under laboratory conditions, it is believed that a consideration of certain factors frequently overlooked in laboratory tests may enable a more correct evaluation of the results reported by others. This should be of aid in reaching any decisions relative to such matters that may be necessary in carrying on public health activities.

Compatibility

The term "quaternary ammonium" defines the chemical structure of these compounds, the water solutions of which dissociate into two ions, one a complex carbon-nitrogen structure called a "cation" being responsible for the germicidal effects, thus accounting for the term "cationic germicides" often applied to these compounds. The surface activity and anti-bacterial effectiveness are reportedly due to the size and complexity of the cation group.

All cationic germicides are incompatible and are neutralized by anionic substances such as soaps and synthetic organic detergents of the anionic type. The common wetting agents and certain alkalies generally reduce or destroy the germicidal properties of quaternaries, hence such cleaning agents must be completely removed by thorough rinsing before sanitizing with quaternaries. Claims have been made that certain alkalies are compatible with certain quaternaries, and inasmuch as their germicidal action is supposedly increased in alkaline solution, such alkalies have in some instances been combined with the quaternary. In other instances quaternaries have been compounded with compatible alkalies and sequestering agents added to provide water softening properties.

Germicidal Properties

The quaternaries have been reported to exhibit remarkable germicidal activity, completely killing various microorganisms on very short contact time in relatively high dilutions. Their potency is frequently expressed in terms of phenol coefficients, although most workers agree that the phenol coefficient is not a suitable means of evaluating quaternary germicides, and that tests designed to approximate actual conditions of use are preferable. McCulloch, Hauge, and Migaki (1948) believed that "phenol coefficient values of quaternaries are dangerously misleading and should not be included on the label or in advertising."

One of the characteristics of quaternaries is their bacteriostatic activity, wherein the microorganisms are temporarily inactivated. Such action occurs in more dilute solutions where concentrated solutions are bactericidal. Differentiation is ordinarily made by preparing subcultures as controls for bacteriostasis.

Chemical Testing Methods

Insofar as we have been able to determine, none of the chemical testing methods now available measures the bactericidal factor of quaternaries. Similarly, McCulloch, Hauge, and Migaki (1948) concluded that although many companies have developed or are developing field test kits, none that they obtained was "capable of differentiating between quaternary ammonium compounds of high and of low bactericidal powers, or between free and active quaternary ammonium compounds in solution and those which have been partially or totally inactivated by combination with certain materials which might be in water or on dishes. Moreover, no test kit has been calibrated to give a simple reading with all types of quaternary ammonium compounds now offered for sanitation."

EVALUATION OF GERMICIDES

Wolf (1946) concluded that "the ideal evaluation of a new germicide would involve:

(1) A preliminary germicidal potency test, either a phenol coefficient or a killing time determination at different concentrations.

(2) Follow-up studies of the effect of such factors as pH, organic matter, bacteriostatic versus bactericidal action, organism specificity, so-called concentration coefficient, and possible neutralizing agents upon the germicide. These studies are to be tempered in all cases by the application that the manufacturer wants to make of his product."

Reddish (1946) similarly stated that "The phenol coefficient is applicable only to disinfectants which are chemically related to phenol and is not suitable for testing disinfectants not chemically related to phenol, such as chlorine compounds, quaternary ammonium compounds, mercury compounds, formalin, iodine, etc. Instead of using the phenol coefficient method of test, or modifications of it, and then attempting to interpret those results in terms of practical values, the results of practical tests must first be determined and then laboratory tests be devised accordingly." He concluded that "The factor of safety should involve the use of organic matter in the test, a time period shorter than that used in practice, a temperature of test lower than that used in dishwashing, the number of organisms should be greater than ordinarily found under practical conditions, and the resistance of the test organism should be representative of the most resistant found under practical conditions. The laboratory test should be a practical test, a 'use-dilution' test which simulates practical conditions of use."

Armbruster and Ridenour (1947) in discussing the introduction of quaternary ammonium compounds and other cationics into the field of sanitation, emphasized need for a suitable and practical method or medium that will show a true bactericidal rather than a bacteriostatic end point. McCulloch, Hauge, and Migaki (1948) reported that data published by the manufacturers of quaternary ammonium compounds were, for the most part, found to be accurate. However, "it appears that the three important methods of evaluating bactericides: the phenol coefficient method, the plate count technics which use 99 percent to 99.99 percent reduction to establish the rate

* Presented at Annual Meeting of International Association of Milk and Food Sanitarians, Philadelphia, Pa., October 23, 1948.

of kill and extrapolate to supposed extinction, and the swab technic as applied to eating utensils; all give data which indicate the quaternary ammonium compounds to be much more efficient than they actually are."

EFFECT OF WATERS

The Public Health Service Water and Sanitation Investigations Station at Cincinnati, Ohio, has completed a series of studies of quaternary ammonium compounds. A statement prepared in 1947 reported some of the factors which affect their bactericidal efficiency and emphasized the adverse effects of interfering substances, organic or inorganic, in the waters in which the bactericidal agents are used. It was concluded that "pending the development of residual tests which provide an accurate measure of bactericidal efficiency, anyone contemplating the use of such compounds for disinfection would be well advised to make bacteriological tests of the product under consideration in the water to be used and under the conditions in which it will be used." Ridenour and Armbruster (1948) similarly reported that the character of the water used has a marked effect on sanitizing efficiency.

Shere (1948) reported that "Studies made during the past year or so have developed rather clear-cut data showing that the water used for making up disinfecting solutions with quaternaries can cause marked variation in the germicidal power of the resulting solutions. This is particularly true of waters of different hardness." He reported studies showing the results on the effect of varying water hardness on six of the more widely distributed quaternary ammonium compounds and a hypochlorite. There was no obvious sign, other than the bacteriological results, that the quaternaries were so much affected by the water hardness. "The solutions stayed clear and a chemical titration for quarternary content showed no difference between soft and hard water." However, the quaternaries required from two to 400 times the concentration to kill in water of 400 parts per million hardness that they did in distilled water, while sodium hypochlorite was unaffected.

Mueller and Seeley (1948) tested natural waters and also waters to which various common ions had been added. They reported "No close correlation was noted between water hardness as measured by standard soap titration and the germicidal potency of the quaternary. Differences in hydrogen-ion concentration found in the natural waters examined had no significant effect on the quaternary. The cations calcium, magnesium, and ferric iron decreased the germicidal potency of the quaternary, while potassium, sodium, and lithium had no adverse effect. Ferric iron was considerably more detrimental than calcium or magnesium, which have similar effects on the quaternary. When the water contained as much as 1000 p.p.m. of calcium or magnesium, the 200 p.p.m. of quaternary was sufficiently potent to give approximately 100 percent kill on *E. coli* after 8 minutes' contact, while as little as 10 p.p.m. of ferric iron completely inactivated the quaternary. The anions studied were chlorides, sulfates, nitrates, and carbonates, and no adverse effect was noted."

INHIBITORS

Quisno, Gibby, and Foter (1946) reported that with the older, less potent cresols and phenolic compounds, simple dilution served as an effective and practical means of distinguishing between bactericidal and bacteriostatic action. "The amount of germicide transferred from the medication tube to the subculture broth was insufficient to exert any bacteriostatic effect. However, the dilution method becomes impractical with compounds which are bacteriostatic in high dilution." They stated that "Formulation of a medium which would have an analogous effect upon the cationic germicides appeared to be the only effective and usable *in vitro* method for overcoming the powerful bacteriostatic effects of these compounds. Such a medium should be capable of neutralizing the largest amount of germicide which would be transferred into the subcultures under actual test conditions. The medium should be clear and should be easy to prepare."

"A high degree of neutralization and a clear, easily prepared medium was obtained by the addition of lecithin (from American Lecithin Co., Inc.) and Tween 80 (a polyoxyethylene derivative of sorbitan monooleate obtained from Atlas Powder Co.) to standard F.D.A. broth or any other good subculture medium. Lecithin acts as the chief neutralizer while the Tween acts as a solubilizing and dispersing agent for the lecithin."

Weber and Black [1948 (a)] investigated compounds such as lecithin and naphuride sodium which had previously been used, and also certain other anionic and non-ionic detergents with reference to their possible use as inhibitors for neutralizing the germicidal action of quaternary ammonium compounds. Nine different types of quaternaries were studied, and nearly fifty substances were tested for possible inhibitory properties. Many compounds were "screened out" because of one or more undesirable characteristics.

Detailed results have been reported in the September, 1948, issue of *Soap and Sanitary Chemicals*, and those especially interested are referred to that publication. From the experiments therein reported, generally employing a culture of *Escherichia coli*, it was determined that only two of the inhibitors, namely lecithin and naphuride sodium, appeared worthy of further study.

In a second paper to appear in the October, 1948, issue of *Soap and Sanitary Chemicals*, Weber and Black [1948 (b)] report upon the relative efficiency of these better inhibitors, using a variety of test organisms. Tables 1 and 4 from that article (listed herein as Tables 1 and 2 respectively) illustrate the difference in sensitiveness to bacteriostatic action of the several cultures employed. From Table 1 it may be seen that the strain of *E. coli* and another Gram negative rod isolated from food utensils could not form colonies in concentrations of 10 mg. of quaternary per dish, but could with 1 mg. The cultures of *Staphylococcus aureus* and *Micrococcus caseolyticus* did not form colonies with 1.0 mg. or even with 0.1 mg., but could with 0.01 mg. of quaternary per dish. A strain of sarcina isolated from food utensils was even more sensitive, and although it could not tolerate 0.01 mg., did form colonies with only 0.001 mg. of quaternary per dish. By use of this sensitive organism it was possible to establish other facts bearing on bacteriostatic action of quaternaries from the standpoint of inhibiting such action.

TABLE 1 †

INHIBITION OF COLONY FORMATION DUE TO GRADED CONCENTRATION OF QUATERNARY AMMONIUM COMPOUND IN AGAR USING VARIOUS TEST ORGANISMS

Results reported as colonies per petri dish following incubation at 37° C. for 48–72 hours

	Milligrams of Q.A.C. per petri dish*						
Organism	*0*	*10^{-4}*	*10^{-3}*	*10^{-2}*	*10^{-1}*	*1*	*10*
Escherichia coli	213	...	200	219	212	202	0
Gram negative rod (399–1) no spores	484	521	450	451	490	158	0
Staphylococcus aureus	97	74	101	106	0	0	..
Micrococcus caseolyticus	94	98	118	40	0	0	..
Sarcina (399–2)	169	161	152	0	0	0	..

* Alkyl Dimethyl Benzyl Ammonium Chloride. Almost identical results were observed with the same concentrations of Di-isobutyl Phenoxy Ethoxy Ethyl Dimethyl Benzyl Ammonium Chloride.
† Weber and Black, listed as Table 1 in *Soap and Sanitary Chemicals*, October, 1948.

From Table 2 it can be seen that naphuride sodium was not adequate for preventing bacteriostatic action, inasmuch as no colonies developed when certain platings were made using standard agar, whereas when duplicate preparations were plated with similar agar containing lecithin as an inhibitor, colonies did develop.

TABLE 2†

RELATIVE EFFICIENCY OF INHIBITORS FOR QUATERNARIES AS INDICATED BY EXPOSURE AT 25° C. OF CULTURE 399-2 (SARCINA) FOR SPECIFIED TIMES IN 10 ML. OF BUFFERED WATER (pH 7.2)

Results reported as colony counts per petri dish comparing platings with Standard TGE and Lecithin TGE agar; 37° C.; 48–72 hours

Inhibitor		*Lecithin* (1)					*Naphuride Sodium*					*None*	
Milligrams		200	200	200	200	200	200	200	200	200	200	0	0
Quaternary (2) Milligrams		0	0.2	0.4	0.8	2.0	0	0.2	0.4	0.8	2.0	0	0.2
Ratio Inhibitor / Quaternary			1000/1	500/1	250/1	100/1		1000/1	500/1	250/1	100/1		
Exposure	*Medium*												
0–10 Minutes	TGE (3)	160	135	46	0	0	163	0	0	0	0	181	0
	Lecithin (4)	149	145	64	0	0	135	143	154	0	0	137	0
1 Hour	TGE	148	120	41	0	0	168	0	0	0	0	151	0
	Lecithin	134	105	65	0	0	105	167	122	0	0	105	0
5 Hours	TGE	122	90	32	0	0	128	0	0	0	0	118	0
	Lecithin	121	LA*	LA*	0	0	118	43	11	0	0	79	0
24 Hours	TGE	148	108	38	0	0	133	0	0	0	0	3	0
	Lecithin	130	132	104	0	0	164	0	1	16	0	0	0

* LA — Laboratory Accident
† Weber and Black, listed as Table 4 in *Soap and Sanitary Chemicals*, October, 1948.
(1) Lecithin (nsolectin in tween 80).
(2) Alkyl Dimethyl Benzyl Ammonium Chloride.
(3) Standard Tryptone Glucose Extract Agar
(4) 1 gram lecithin per liter TGE Agar.

This material has been presented to illustrate the necessity of employing adequate and effective inhibitors in evaluating the germicidal efficiency of quaternaries, otherwise the results may indicate a compound to have germicidal properties that it does not actually possess.

LABORATORY TEST USING INHIBITORS

In the absence of a reliable and rapid field test actually indicative of the residual bactericidal properties of the sanitizing solution employed, other means must be used to determine if a product is an efficient bactericide under the local conditions of use. The effectiveness may be estimated by means of a suitable laboratory testing procedure, for example one involving use-dilution with a heavy load of resistant organisms, a sufficient amount of a specific inhibitor for the germicide under test, with the test performed in the water in which the sanitizing solution is to be diluted. Then, if the particular compound is found to give a 100 percent kill quickly, for example in 30 seconds or so, it would appear feasible to utilize the germicide under actual operating conditions and determine its actual performance by bacteriological tests of the sanitized equipment.

Unfortunately, many of the results reported on the efficiency of quaternaries have been based on methods not incorporating satisfactory inhibitors, and hence, as has been pointed out by McCulloch, Hauge, and Migaki, 1948, "indicate the quaternary ammonium compounds to be much more efficient than they actually are."

Following practical experience in the use of quaternaries and combined detergent-sanitizers for sanitizing food utensils, Weber and Black [1948 (c)] developed a laboratory procedure for evaluating the practical performance of quaternary ammonium and other germicides proposed for sanitizing utensils. This is described in an article appearing in the October, 1948, *American Journal of Public Health.* Mimeographed directions for actually performing the test, with more complete notes on the preparation of materials, are available upon request to the authors. Following a review of various methods proposed for the purpose, a survivor-curve procedure was selected as more nearly representing practical conditions. From various sources and experiments it appeared that a test solution containing 100 million bacteria per milliliter would correspond to a heavy load of contamination on food utensils. The volume selected was intentionally small to facilitate testing by local laboratories. For similar reasons the test organisms were suspended in solution, and the end point selected was 100 percent kill of these. The test was designed to be carried out at room temperature. Short exposure times were selected, from 15 seconds to 5 minutes. The procedure is particularly adapted to testing compounds locally in the type of water in which they will be diluted for use.

Comparative studies and interpretation of results have been summarized in the October *American Journal of Public Health,* and those especially interested are referred to the original article. It was concluded that the time required for a 100 percent kill by this testing procedure would appear to be a fair index of the germicidal efficiency of quaternaries or other germicides used for sanitizing utensils. Compounds appearing satisfactory by the laboratory test could then be observed under actual usage, where opportunity exists for periodic bacteriological tests of the sanitized equipment to insure that the end results are satisfactory.

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QUALITY MILK AWARDS

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REWARDING a person for doing a good job is nothing new to industry, business, and the professions; but the farmer frequently goes unnoticed in his vocational accomplishments. Since 1944 this health department has been giving special recognition to dairy farmers producing milk of higher quality than required by the Standard Milk Ordinance.

While it is true that in many areas, including this one, the designation "Grade A Dairy Farm" distinguishes the real milk producer from the ordinary milk shipper, there is usually room for improvement even in milksheds rating 90 percent or more. Regulations like the Standard Milk Ordinance which must apply to large numbers of establishments in all sections of the country necessarily allow occasional non-compliance with the ordinance without lowering the grade. Whenever a dairy farmer, however, produces milk throughout the year without violating a single major item of the ordinance and without exceeding the bacterial standard on any count, he is superior to the average grade A dairyman.

In the fall of 1943 when this local health department substituted the direct microscopic count for the methylene-blue test and competent milk inspectors were visiting each farm five or six times a year, it became apparent that even with such stringent supervision some of the dairymen were able to maintain almost perfect records. Month after month the direct microscopic test would show a minimum count and farm inspections resulted in unmarked report forms. In order to show these milk producers that the health department recognized their accomplishments, the merit award system was inaugurated.

It was with some misgivings that the project was undertaken because of the realization that the designation of superior grades of milk by official health agencies is undesirable. The merit awards, however, were to resemble an "honor roll" rather than another grade. Experience over a considerable period of time has indicated that such a plan, on a voluntary basis, can improve appreciably the quality of milk above that required by ordinance.

When the system of awarding certificates of merit was initiated five years ago, seventeen dairymen were recognized as outstanding. Without lowering the standards necessary to earn the award, this number grew to 210 for 1948. In striving to achieve the awards, dairy farmers constantly maintain better sanitary conditions and reduce the amount of necessary supervision. Dairy farm inspections and laboratory examinations may be held to a minimum at those farms which consistently produce an excellent product, thus enabling more time to be allotted to those farms in need of the most attention.

Pasteurization plants in the milkshed have recognized the value of these awards. Two of the larger dairies provide attractive frames to their patrons receiving the certificates. One milk plant distributes the health department awards at sectional dairy farmer meetings, and this year, on its own initiative, decided to present a special trophy to its dairymen who for five consecutive years have earned a certificate.

Interest in the plan continues to grow among the dairy farmers as the location of award winners becomes more widespread in the 17,000 square-mile milkshed. Newspapers, dairy publications, and radio stations publicize the presentations each year by explaining the basis for the award and announcing the name and addresses of the recipients. It has become evident that in addition to stimulating the production of a higher-quality milk, the issuance of merit awards has improved relations between the health department, the pasteurization plants, and the milk producers.

Frozen Pre-Cooked Foods

(Continued from page 213)

ples were too few to permit final judgment as to the true quality of the products tested.

We wish to acknowledge the assistance of Miss Caroline Oldenbusch of this Bureau who carried out the tests for enteric pathogens.

We are also indebted to Mr. Frank Rendler of the Bureau of Food and Drugs who secured the food samples studied.

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THE CONTROL OF FOOD POISONING IN AN ARMY POST

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INTRODUCTION

DURING World War II a number of large and small outbreaks of food poisoning occurred in Army messes.[1] It should not be concluded, however, that the incidence of food poisoning was greater in Army messes than in comparable civilian restaurants and food establishments.[2] Nor should one conclude that Army sanitation is lax; the reverse is generally true. The fact that numerous food-poisoning outbreaks were reported in the Army during the recent War reflects the strict supervision and control the Army was able to maintain. Sporadic outbreaks involving the major portion of 250 or so men of a company mess or perhaps 1000 or more men in a battalion or regimental mess cannot go unnoticed. Generally, men messing together are quartered in the same barracks or bivouac. Because of the nature of food poisoning, it is ordinarily not possible to conceal an outbreak.

On the other hand, a comparable outbreak of equal magnitude in a civilian restaurant may go entirely unnoticed. Each victim is served his "food poisoning special", after which he returns to his abode to suffer alone without realizing that the others who were likewise served are also in agony. Occasionally two or more persons dining out together may "compare notes" and realize that they have both been poisoned but generally it is only when a large number of persons are served together from a common food source as at an institution, a banquet, or picnic that poisoning becomes evident. Often the symptoms of poisoning appear before the group has disbanded.[3]

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Because of the fact that Army messing is controlled, it was possible during the recent War to make certain observations which would not have been possible in civilian food establishments except under rather unusual conditions.

PRELIMINARY OBSERVATIONS

Observations were begun at one Army Post early in the summer of 1942. Outbreaks of food poisoning were reported to the office of the Post Surgeon, and in each instance an immediate investigation was made. These outbreaks were limited to men messing together, eating food prepared and served from an individual mess. By correlating the data relative to the food eaten with data of cases actually affected, it was frequently possible to "incriminate" a given food. However, minor discrepancies in correlation were often noted. As would be expected, all men eating a food containing a poisonous agent are not equally susceptible, and some will not show symptoms.[1] Also, the poisonous agent may not be distributed uniformly throughout a given food. On the other hand, it was frequently observed that a few men who had not eaten the "incriminated" food also stated that they were ill. Whether or not these few cases were purely psychological or were just men malingering was not generally determined. It is possible also that some of these cases were food poisoning resulting from food secured from civilian restaurants or from other sources.

It was not always possible to secure food samples for laboratory analyses, because small amounts of left-over readily-perishable foods were often discarded immediately after serving, or frequently symptoms did not develop until several hours later, the suspected food having all been served or discarded previously. When food samples were available, in a number of instances either organisms of the genus *Salmonella* or *Staphylococcus* were isolated and observed to be present in high numbers.[4] Food poisoning as referred to in this report includes possible *Salmonella* infections. Because of the number of outbreaks at the beginning of these observations, it became impractical to perform detailed laboratory studies on each individual sample.

INCRIMINATING FOODS

Foods most frequently incriminated were: (1) Potato salad, chicken salad, ham salad, and other similar foods in which certain of the ingredients were first thoroughly cooked, then handled, and finally placed in the refrigerator and held for several hours at an inadequate refrigeration temperature. (2) Non-acid puddings and non-acid cream-filled pies which had either been adequately baked, then contaminated by improper handling and stored for some time at incubation temperature, or possibly which had been inadequately baked and stored at an incubation temperature with or without contamination from handling. Occasionally incubation was prolonged between preparation and cooking. (3) Turkeys and other fowl stuffed and inadequately baked, with or without a period of inadequate refrigeration before or after baking. (4) Ham, meat loaf, and other meats which were first baked, either adequately or inadequately,[5] and then sliced, resulting in a considerable amount of handling and with or without a holding period after slicing. (5) Acid drinks prepared in zinc-coated (galvanized iron) cans[6] misused for serving in the field. Symptoms usually developed very soon after consumption of such drinks—usually within a few minutes.[3] Other types of metallic poisonings were not frequently observed.

It is possible that isolated cases of food infection[3,7] may have resulted from consumption of contaminated prepared foods or raw vegetables, but unless a large number of cases occur at one time, it is not likely to be traced. No outbreaks of this nature were noted during these observations.

That food poisoning was a common occurrence[1] and that men were somewhat familiar with it, was evidenced by names attributed to an outbreak such as "the G.I.'s." There was the common belief by Army mess personnel that all food poisoning was caused by inadequate washing of food utensils,[8] resulting in a film of residual soap on the mess gear and utensil; soap was erroneously believed to be the responsible agent.

ILLUSTRATIVE CASES

One outbreak which illustrates typically the sequence of events which often took place, occurred during July when the weather was extremely hot. The mess sergeant of the company mess involved was on leave for a few days and one of the first cooks was in charge. Bread pudding was prepared in a 100-ration pan Saturday evening by the baker. The bread was broken into pieces by hand which resulted, of course, in a fair amount of contamination. Following this, milk, eggs, spices, etc., were added, resulting in an ideal culture medium for the bacteria which had originated from the handling of the bread, as well as possibly from other ingredients.[3,9,10,11] This bread pudding was baked, probably inadequately,[12] in a deep layer in the pan and stored at a high room temperature (unrefrigerated) from Saturday night until Monday noon, following which it was served in the company mess at the noon meal. By the middle of the afternoon rather violent and severe gastro-intestinal symptoms appeared in the majority of the men who had eaten the previous meal in the company mess. The men who were ill were suffering to such an extent that hospitalization was ordered. All cases recovered within two or three days.[1]

Food poisoning was in no way

limited to enlisted men's messes, or even to messes at all, for that matter. In one officers' mess, a civilian cook opened a No. 10 can of cream-style corn and then changed the menu and set the can of corn on a shelf, unrefrigerated until the following day. The next day the corn (probably initially contaminated by can opener or thumb, or both) was cooked and served for the noon-day meal. The major portion of those messing at this officers' mess became ill during the next few hours. Isolated cases, in a number of instances, resulted from food prepared in the homes.

A company of men messing in the field one hot day was served lemonade from a galvanized iron can. Within about 30 minutes a large number of the men were vomiting. Upon inspection it was observed that there was a black coating of soluble metallic salt over the entire inside surface of the can. Metallic poisonings of this type ordinarily strike soon—within a few minutes.[3]

These general types of sequence occurred frequently. Generally, however, soldiers were not hospitalized. It became quite clear very soon that first of all, the mess personnel were not adequately trained for coping with the control of food poisoning,[13] and secondly, that *all personnel* in the mess must be trained because a number of the outbreaks occurred when the mess sergeant was away on pass and a first, or even a second, cook was left in charge. It was clearly shown that "a chain can be no stronger than its weakest link" and even if the mess sergeant and the first cooks were extremely careful, occasionally a second cook, cook's helper, or baker might be responsible for immoblizing a company (or regiment) through food poisoning.

Control Program

With these facts from several months investigations at hand, and with a view to eliminating or certainly reducing the incidence of food poisoning, an intensive program was established. A directive in the form of a memorandum, Subject: "Food Poisoning", based on references available, both civilian [3, 15, 16] and military,[6, 14, 17] was prepared and issued to each mess on the Post, with orders that all mess personnel immediately familiarize themselves with it and that the memorandum be *permanently* posted on the bulletin board of each mess hall. Service clubs and post exchanges were likewise included. An exact quotation of this memodranum is to be found in the Appendix at the end of this article.

Immediately following the issuance of this memorandum, an order was issued requiring all mess personnel to attend a lecture of about one hour duration on food sanitation, with particular emphasis placed on food-poisoning control. Classes were "staggered" so as not to disrupt normal operation of the messes.

Following the initial food handlers' classes for all mess personnel, similar classes were instituted for both military and civilian food handlers in service clubs and post exchanges. These food handlers' classes were continued for all military and civilian food handlers on the Post, so that new personnel entering the Post could be trained before being placed in responsible food-handling assignments. The course was improved by the use of both military and civilian training films, and by the inclusion of demonstrations.

Cards instructing: "FOOD HANDLERS — COOKS — KITCHEN POLICE, WASH HANDS with SOAP and WATER AFTER USING LATRINE—Avoid Spreading INFECTIOUS DISEASES" were posted in each mess kitchen, post exchange, service club kitchen, and latrine at this Post.

The delivery and sale of non-acid cream-filled pies, chicken salad, and egg salad sandwiches, and similar foods for use in service clubs, post exchanges, and messes were prohibited. Commercial bakeries and other civilian food establishments were advised of this policy and spot checks were made of delivery trucks entering the Post to enforce compliance. Sanitary inspections were made of establishments furnishing prepared foods to the Post.

Cooperative projects were worked out with local county and city health officers to enforce, as far as possible, a similar policy in the area surrounding the Post. Spot inspections were made of taverns and food establishments adjacent to the Post by military and civilian health officers.

The master menu for the Post was altered to eliminate the preparation and serving of foods which could not be handled in compliance with the food-poisoning memorandum. Fruit pies were substituted for cream-filled pies and extremely perishable or "susceptible" foods were eliminated.

Spot inspections were made of messes, service club kitchens, and post-exchange food counters at all serving hours. Any excessive or unwarranted food handling was noted and corrected *on the spot*. It was ascertained at the time of each inspection that the food-poisoning memorandum was posted and food handlers were questioned regarding the details of the memorandum. Temperatures of foods and the amount of time elapsing between preparation and serving were noted. Left-over foods were checked as to type and depth of layer in the refrigerator. In some cases, food samples were sent to the laboratory for further study.

Results

At the Army Post under observation, a number * of food poisoning outbreaks occurred each month during the early part of the summer of 1943. Following the issuing of the initial memorandum on food-poisoning control the 19th of July 1943, food poisoning outbreaks stopped *immediately* and none was reported throughout the summer and fall of 1943. In January 1944, an outbreak occurred in one company mess due to some rice pudding which had been held at room temperature for a period of time and may not have been adequately cooked in preparation. The following May there was an outbreak in a company mess involving the major portion of the men, due to potato salad which was prepared the day before serving and inadequately refrigerated. Throughout 1944, 1945, and most of of 1946, beyond which date no specific information is available, there was an outbreak of food poisoning in a mess averaging about every 5 to 7 months, and in each instance it was demonstrated upon investigation that there was a violation of the food-poisoning memorandum. Usually this violation was in the form of preparing foods such as potato salad, for example, too far ahead of serving and placing it in a deep layer in a container and attempting to refrigerate it.

* Statistics not reported.

Discussion

Certain types of foods are known to be especially likely to be responsible for food poisoning and food infection. This is particularly true of many unrefrigerated foods in warm weather. Non-acid foods which are freely handled during preparation and are served without cooking or are only partially cooked may be responsible for illness. Organisms of the genus *Staphylococcus* (*Micrococcus*) or *Streptococcus* from the nose and throat, or *Salmonella* or other enteric organisms from the intestinal tract of man or from other sources such as infected raw meats,[3, 18] insects, rodents, etc., find their way into the foods through food handling during preparation or by other means (improper storage). If such contaminated foods are held without adequate refrigeration for a period of a few hours, permitting incubation there may be developed toxins, as well as high numbers of pathogenic organisms. Factors of importance in this connection are: (1) Non-acid foods are conductive to the growth of certain types of organisms and the production of toxins which may be responsible for food poisoning and food infection. (2)

Several hours may elapse before the center portions of some foods placed in a refrigerator reach refrigeration temperature, and this would allow adequate time for the production of both high counts of bacteria and large amounts of toxin. (3) In a non-acid food, cooking is less effective for "pasteurizing" or sterilizing foods than in an acid medium. (4) When a high bacterial count is built up by incubation of the contaminated food, it requires a longer time or a higher temperature, or both, to destroy completely the microorganisms during cooking. (5) The bacteria may be partially or completely destroyed, yet toxins developed in the food may not be entirely eliminated by the cooking process.[3, 4] (6) Undoubtedly large amounts of even the heat-labile toxins would be more difficult to destroy by cooking than small amounts, other factors being equal. The pH of the food may be of considerable practical significance in this reaction.

Control factors which are within the domain of food handlers are recommended as follows: (1) Prevent excessive handling or other contamination of foods initially, by maintaining personal cleanliness, use of food forceps, forks, etc., and by adequate protection of foods. (2) Shorten the time between preparation and cooking and between cooking and serving, or between preparation and serving for foods handled after cooking. (3) Adequately cook foods (including left-over foods). (4) Adequately refrigerate (just above freezing) all foods which are likely to be responsible for food poisoning. It is not believed that contamination from insects and rodents or improperly cooked infected meat, (eggs, milk, etc.) was the cause of a great number of outbreaks. However, indications are that in some instances baked stuffed turkeys and ham[18, 19] were responsible for some outbreaks of illness.

Changes in physical properties cannot be relied upon for detecting poisonous food. *Knowing the exact history* of the food is the most important *one* factor in controlling food poisoning, and in deciding whether a given food is safe for consumption. Only the food handler can be sure of this and he must be thoroughly trained and competent.

The problem of food poisoning at this Army Post appeared largely to center around the control of the genera *Staphylococcus* (*Micrococcus*), *Streptococcus,* and *Salmonella,* and not the botulism organism. There is need for continued investigations relative to the control of these non-spore-forming microorganisms in foods.

In light of newer knowledge regarding the rapid development of food-poisoning toxin or high bacterial counts resulting in a greater initial inoculation in the case of food infections, there is need for a restudy of the field of food refrigeration[20] because of the poor heat conduction of certain foods when in deep layers in the refrigerator.

Experiments conducted[21] in the hospital laboratory (1943) at the Army Post, revealed that when organisms of the genera *Salmonella* and *Staphylococcus* were each inoculated into a separate lemon cream pie, they were not recovered after 24 hours at room temperature. When these lemon cream pies were held for a few days at room temperature, an alcoholic fermentation resulted due to yeasts. Other types of cream-filled pies supported growth of *Salmonella* organisms. *Staphylococcus* organisms also grew abundantly in these cream-filled pies. No cases of food poisoning were observed at this Post due to lemon cream pie. The pH is apparently the limiting factor, however, additional investigations need to be made in this field. Catheart *et al.* (1947)[22] have reported studies relative to the growth of food poisoning organisms in pastry fillings under conditions of low pH. The Army has recognized that acid foods are less likely to be responsible for food poisoning. A circular[14] prepared early in the War recommends the addition of vinegar and pickle mixes to sandwiches to aid in preservation.[13]

The procedure described in this report for controlling food poisoning in Army messes at this Post can well be applied to the control of food poisoning in civilian restaurants and other food establishments, including the home. If health authorities responsible for sanitary control of drug-store sandwich bars, soda-fountain counters, and even some of our largest restaurants could observe each outbreak of food poisoning, as is possible to do in the Army, they could not afford to sit idly by while poorly-trained food handlers dispense chicken salad sandwiches and other similar foods which have been heavily contaminated during preparation and held for long periods of time at "so-called" refrigeration temperatures.

In connection with this study, samples of chicken salad were taken for laboratory analyses from a drug-store sandwich bar in a city in the vicinity of the Post. Bacterial plate counts were extremely high (in the millions per gram)[21] and an inspection was made to investigate the method of preparation and handling. It was learned that chicken salad, egg salad, and other similar foods were prepared by hand the afternoon before delivery in a central kitchen in a city about 10 miles away. Delivery was made to several drug stores (as this was a chain drug-store company) *early* the following morning. The particular branch drug store from which the laboratory sample of chicken salad was taken did not normally open until about 8:00 A. M. or later, and since the delivery man could not get into the store, he left the chicken salad in an unrefrigerated container on the sidewalk in the hot summer sun. It was some time near 9:00 A. M. or later when the chiken salad was actually placed in a refrigerator or in a refrigerated counter and was undoubtedly several hours later before the mass was cooled to refrigeration temperature.

Because this period of unrefrigerated exposure, together with the heavy initial contamination, was conducive to the production of foods likely to be responsible for food poisoning, the manager of the chain drug store kitchen was warned. In the meantime the wife of one of the city health department sanitary inspectors inadvertently stopped in at this drug store in question and ate a chicken salad sandwich. Within about two hours she became violently ill with what appeared to be typical staphylococcus food poisoning. The local health department took action and improved the situation.

This chain of events could be repeated many times with other types of foods. In a number of instances, potato salad was being prepared in a city about 50 miles away and delivered to a large super market in which it was held in open pans inside a poorly refrigerated glass counter for several days—until sold!

The transportation of heavily contaminated, unrefrigerated, non-acid foods from one city to another, requiring considerable time, is a dangerous procedure. Baked pastries likely to cause food poisoning should, of course, be first *thoroughly* baked, then protected from contamination through handling or otherwise, and kept under *adequate* refrigeration at *all times*—even in the delivery truck. Even with these precautions, a "break in the chain of control" may result in a sporadic outbreak of food poisoning.

In the Army the problem of preparing and serving foods likely to cause food poisoning is of no minor magnitude. This problem is even augmented in field serving without complete refrigeration and the menu often has to be "tailored" to fit the needs for sanitary precautions. Similar changes in the menu should be considered in civilian food establishments and in the home, especially for picnics.

CONCLUSIONS

The program described in this report, which was effective for the con-

trol of food poisoning in an Army Post, may well be considered for use by health officers responsible for sanitary control of civilian restaurants and other food establishments, as well as in the home. Important points to be included in an effective program should be: (1) Education of all food handlers concerned through food handlers' schools, demonstrations, training films, etc. (2) Posting of memoranda for the control of food poisoning in each food establishment kitchen. (3) Frequent inspections by health department officials to ascertain that each food handler is *familiar with details* of the food poisoning memorandum, and to ascertain that there is strict compliance with recommendations. (4) Spot-checking of occasional food samples by laboratory procedures to insure that foods are being properly cared for. (5) Provisions for adequately training new food handlers before they are assigned to duty.

Some outbreaks observed indicate that there is still need for further study to solve completely some of the perplexing control problems. These problems are largely of a practical nature such as the temperatures and times of refrigeration, cooking, etc., as well as the relationship of pH to growth and toxin production of microorganisms responsible for food poisoning.

While the medical examination of each food handler is important both initially and periodically, from a practical standpoint it is often not possible to make a complete examination, including complete laboratory analyses. Because of this, it is believed that much greater returns for effort expended can be realized by placing emphasis on reduction of food handling and food contamination for reducing the incidence of food poisoning and food infection. It is clear, however, that a medical examination is important from the standpoint of eliminating known human sources of infection.

Summary

A program which was effective for controlling food poisoning at an Army Post during the recent war was described. It was pointed out that Army messing conditions are such that even a small outbreak of food poisoning is obvious, whereas it is difficult, if not impossible, to trace a similar outbreak in a civilian food establishment except where large groups are eating together as at a banquet, picnic or institution. This type of procedure should be effective for controlling food poisoning in civilian food establishments, and in the home. The one most important factor in deciding if a food is safe for consumption is to know the *exact* history of the food as to preparation, refrigeration, time of holding, adequacy of cooking and other factors. Only the food handler can be sure of all these factors, and it is important that he be thoroughly and adequately trained.

Appendix

Food Poisoning Control Memorandum successfully employed in the Army:

"1. Periodic outbreaks of food poisoning have been observed, particularly during warm weather, due to improper preparation and serving of foods by mess personnel. With continued emphasis placed on food conservation, food poisoning sometimes results, due to the carrying over of certain types of foods. Food poisoning, characterized by vomiting, diarrhea, or both, is caused chiefly by toxins produced by certain bacteria growing in a favorable environment. *The spread of infectious disease germs through food due to excessive food handling should not be overlooked.* These bacteria are commonly found in the nose, throat and intestinal tract of man; the hands are usually contaminated and food which is handled generally becomes well contaminated. *Non-acid puddings (chocolate, vanilla, etc.) custard, pumpkin pie, bread pudding, cream-filled pies (except lemon) cream-filled cakes, potato salad, chicken salad, salmon salad, shrimp salad, pork salad, hash, etc.*, are ideal media for these micro-organisms to grow and produce toxins. Non-acid foods such as those above which are freely handled during preparation and served without subsequent cooking or are only partially cooked, then allowed to incubate at room temperature for period of a few hours, are generally responsible for the observed outbreaks of food poisoning. Foods placed in the refrigerator in deep layers are usually not sufficiently cooled; shallow layers are much more satisfactory.

2. Acid foods, such as fruit pies, *lemon* cream pie, fruit desserts, vegetable salad free of mayonnaise, and fruit gelatin desserts, may generally be stored with safety for a period of a day or so. Generally speaking, fruits and fruit products are not good culture media for food poisoning bacteria, and are reasonably safe. However, acid drinks such as lemonade, coffee and tea, and acid desserts, such as fruit salad and fruit gelatin, should not be stored for long periods of time in *contact with metal* and should *never be placed in zinc-coated containers such as galvanized cans (G.I)*, because of the danger of food poisoning. Contrary to popular belief, foods may be safely stored in the tin cans in which they are packed by the manufacturer, after they have been opened, provided they are properly refrigerated; tin and iron are relatively nontoxic. No cases of food poisoning have been observed due to the storage of acid foods or drinks in aluminum containers and it is considered that the use of aluminum stock pots for such is reasonably safe.

3. The following recommendations are submitted as an aid in the reduction of food poisoning and food infection, and will be carried out by mess personnel:

a. *Thoroughly wash the hands with soap and water* before working with foods and *reduce all food handling to a minimum; avoid contamination of hands by touching face and clothing; make use of utensils such as forks, spoons, forceps, etc. for preparation and serving.*

b. Non-acid foods, such as *puddings (chocolate, vanilla, etc.) custard, pumpkin pie, bread pudding, cream-filled pies (except lemon), cream-filled cakes, potato salad, chicken salad, salmon salad, shrimp salad, pork salad, hash, etc.*, which may be freely handled during preparation and served without subsequent cooking or only partial cooking, should be prepared only a short time before serving, preferably not more than *one hour and in no case more than three hours.* These foods should be refrigerated in a shallow layer so as to facilitate chilling and will not be stored from one meal to the next.

c. Avoid the preparation and serving of acid foods and drinks such as fruit salads, vegetable salads, fruit gelatin dessert, lemonade, orangeade, coffee and tea, in zinc-coated containers.

d. Refrigerate (below 40° F.) left-over foods, such as meats, creamed vegetables, etc., in a shallow layer and serve them the following meal. In the event that it becomes necessary to hold such foods for several hours (e.g. overnight), they may be made much safer by thoroughly cooking and avoiding contamination by handling before subjecting them to adequate refrigeration. Many of the toxins produced by food poisoning bacteria are not destroyed by heat, once they are formed, however, the food poisoning bacteria may be killed, hence any heat treatment of food should be carried out before a long incubation period has elapsed.

4. This memorandum will be posted in each mess hall, service club kitchen, and post exchange kitchen. Reference is made to WD Circulars No. 4, 6 January 1942, and No. 277, 20 August 1942. All mess personnel will familiarize themselves thoroughly with this directive."

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MILK and FOOD SANITATION

DETERGENT-SANITIZERS *

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INTRODUCTION

THERE is little question that improperly cleansed and sanitized eating utensils constitute a health hazard. This discussion, therefore, does not dwell on the subject of why eating utensils should be properly cleansed and sanitized but considers some ways in which the job can be done more effectively.

The chief objective in improving the cleansing and sanitation of eating utensils is the protection of the public with a minimum of cost and labor. If a program for improved santitation can be established with no great increase in labor, then restaurant owners are more likely to cooperate with health authorities.

At present, a common method for cleaning and sanitizing eating utensils is briefly as follows: The utensils are scraped or pre-rinsed, washed in warm detergent solution, rinsed in clean water, placed in sanitizing solution, drained, and dried by heat or cloth. While there are variations of this method, they usually have in common that the cleansing and the sanitizing agent are applied separately.

A new departure from the common method is the use of a detergent-sanitizer, which combines cleaning and an initial sanitizing in one operation. This is so radically different from the old method that a close scrutiny of its merits and limitations seems justified. No doubt, in some people's minds it is still questionable whether it is possible or even desirable to develop a combined cleaner-sanitizer which will do both tasks in one operation. It is hoped that the following discussion will be helpful in evaluating the use of detergent-sanitizers where eating utensils are involved.

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DESCRIPTION OF DETERGENT-SANITIZERS

Detergent-sanitizers are compounded products which have both cleaning and sanitizing properties and incidentally also act as deodorants to some extent. The sanitizing agent in most of these products is a quaternary ammonium salt. Before the quaternaries were so well known, attempts were made to use chlorine in combination with a detergent. Such products did not receive wide acceptance because it is generally known that chlorine will not function efficiently in the presence of a large amount of organic material such as dish wash soil. Because of the difference in stability of the quaternaries in the presence of organic material, they are more suitable than chlorine as the sanitizing agent in a dual-purpose product. These products are now available in both liquid and powder form. In cold climates the liquid product has the disadvantage of freezing, which may break the container. The pH may be between 7 and 10 depending on the ingredients.

Although quaternary ammonium salts are used chiefly as germicides, they do have some detergent action, but not enough to be used alone as detergent-sanitizers. The detergent property varies with the type of quaternary. It has been reported that one type of quaternary is superior in detergency to soap and is about twice as effective in this respect as other quaternary ammonium compounds. There seems to be no correlation between detergency and anti-bacterial action.

Since the detergent properties of the quaternaries are too weak for the product to be used alone as a cleaner-sanitizer, fortification with detergents is necessary. The composition of the detergent part of the dual-purpose products is generally not publicized as much as the sanitizing part. Usually the composition of the detergent part is kept more or less as a trade secret, because considerable technical knowledge is necessary in selecting and properly balancing detergent products which are compatible with the quaternary. The difficulties encountered in successfully compounding a detergent-sanitizer are appreciated more when we realize that the compatibility of each constituent with the quaternary must be known when used in various combinations.

In general, the detergent part consists of one or more of the following ingredients: phosphates, polyphosphates, sodium carbonate, borax, and non-ionic wetting agents.

SOME ADVANTAGES CLAIMED FOR DETERGENT-SANITIZERS

1. *Makes cleaning and sanitizing a simple, single operation.* It has been often stated that detergent-sanitizers make cleaning and sanitizing a simple, single operation. This statement seems to hold true for certain cleaning and sanitizing jobs but needs some qualification. Dual-purpose products have been recommended for use on dairy farms and in dairy plants, other food processing plants, and eating establishments. Wherever equipment can be put to use in a wet or damp condition, no doubt the detergent-sanitizer can be used as a single operation. For example, milking machines and pails after being washed in the detergent-sanitizer solution are drained on a rack, and immediately before use are rinsed with warm water. The thin film of quaternary left on the surface of the utensils theoretically protects them against bacterial contamination from dust from the time they are washed until they are put to use again. It is important to remember that the detergent-sanitizer may have some corrosive action if left in contact with metallic surfaces for any length of time. This will vary with the product and must be taken into consideration when determining the procedure to be used. However, when we consider eating utensils, which should not be put to use in a wet condition, it may not be advisable to do the cleaning and sanitizing in a single operation. A good reason for recommending the after-rinse is the esthetic viewpoint. Often the detergent-sanitizer solution will become loaded with dish wash soil before the solution is changed. While the wash water may be practically sterile, and the utensils effectively sanitized, they may not look clean unless an after-rinse is applied. An after-rinse in a separate tank or compartment with water only is not entirely satisfactory because the tank may not be kept in a sanitary condition. This would result in recontamination of the utensils. An after-rinse applied as a water spray would be less objectionable. However, a pure water-rinse, no matter how applied, is not the best procedure available.

Since eating utensils should be dry when used, and are often stored for some time before they are put into use again, the after-rinse should contain a germicide. The quaternary germicide used in detergent-sanitizers has a characteristic peculiarly suited to this use. Very small residues of a quaternary have strong bacteriostatic power as well as some germicidal power. This small residue left on the surface protects against recontamination from the air and other sources. Thus a sanitizing rinse is desirable even if the eating utensils have been washed in a detergent-sanitizer solution. Now

when the detergent-sanitizer must be followed by a sanitizing rinse, it is no longer a single operation. This point is not emphasized as being a limitation of detergent-sanitizers but a merit because double sanitation gives greater protection. Since nearly all of the bacteria are killed in the initial sanitizing step, the rinse water need not be an ordinary full-strength solution of germicide. The after-rinse could be a half-strength detergent sanitizer solution or a half-strength solution of any good germicide. Any small extra expense involved by the double sanitation of eating utensils seems justified from the public health stand point.

We all know that no matter how much effort is expended, there are always some who will not follow the accepted rules for adequate sanitation. There is likely to be careless or even deliberate omission of the sanitizing after-rinse. With the use of the detergent-sanitizer where initial sanitation is attained as the utensils are washed, the careless worker cannot avoid sanitizing if he washes his utensils at all. Though this is hardly a recommended procedure it affords a considerable degree of safety where these difficult cases are encountered.

2. *Germicidal properties of quaternaries are increased in detergent-sanitizers.*

Studies in the dairy research laboratory have shown that quaternaries in a detergent-sanitizer solution have greater germicidal power than the equivalent amount of quaternary alone. Other investigators have made the same observation. One reason for this increased activity is that quaternaries are more effective at a high pH than at a low pH. Detergent-sanitizers can be adjusted so that the dilution in use is within a pH range for optimum germicidal performance.

Another reason for the increased germicidal activity is that properly formulated alkaline detergent-sanitizers usually contain sequestering agents for calcium and magnesium which are chiefly responsible for water hardness. Quaternaries are not as effective in hard water as in soft water. The data in Table 1 from unpublished work by Mueller and Seeley, University of Massachusetts, show the effect of various concentrations of either calcium or magnesium on the germicidal properties of a quaternary solution containing 200 ppm of active ingredient.

TABLE 1

EFFECT OF CONCENTRATION OF CA OR MG ON GERMICIDAL PROPERTIES OF 200 PPM OF QUATERNARY SOLUTION

Parts per million of Ca or Mg	Time for complete kill of *E. coli* organisms (minutes)
0	½ or less
100	½ or less
200	2
300	3
400	4
600	5
800	6
1000	8

The data show considerable interference with germicidal activity by calcium or magnesium. While hard waters to be used for diluting the quaternary can be readily softened, the detrimental effects of the calcium and magnesium are automatically taken care of by the use of detergent-sanitizers because these products usually contain sequestering agents.

Data by Mueller and Seeley also show that as little as 10 ppm of ferric iron will practically completely inactivate a solution containing 200 ppm of the quaternary. When the same amount of ferric iron was used with a balanced detergent-sanitizer there was no significant inactivation. Thus it is indicated strongly that good detergent-sanitizers have the advantage over straight quaternaries in certain types of waters.

Two eastern dairy plants have studied the effectiveness of the dual purpose combination under actual practical conditions. When a cleaner-sanitizer was used on milking equipment and utensils, the number of thermoduric and thermophilic bacteria were greatly reduced. Similar reports have come to the writers' attention from other sources. While these reports deal with dairy sanitation they undoubtedly give some indication of what to expect in the sanitation of eating utensils.

LIMITATIONS OF DETERGENT-SANITIZERS

1. Skin Irritation.

It so happens that some of the constituents of the detergent part of the detergent-sanitizers may irritate the skin of some people. Where dishes are washed by hand over long periods by people who have a sensitive skin, the skin irritation may be severe enough to limit the use of detergent-sanitizers. Anionic soaps are now commonly used in washing dishes by hand since they are not particularly irritating to the skin. Since most soaps and anionic wetting agents are not compatible they are not used in detergent-sanitizers. No doubt further research will result in non-irritating detergents which are compatible with the quaternaries.

2. Cost.

Another limitation of the detergent-sanitizers is their price. The manufacturers have little choice in the matter of price because some of the materials necessary for a dual-purpose product are expensive. It should be emphasized that the selection of a detergent-sanitizer should be made not on price per pound alone, but also on the results obtainable with this product at the dilutions recommended for use. Each prospective buyer of a detergent-sanitizer should make his own price comparisons when applied to his own working conditions. For example, actual figures from one large dairy chain have established a cost of five cents per day for the cleaner-sanitizer material on a one unit farm.

PRECAUTIONS IN USING DETERGENT-SANITIZERS

The importance of using the detergent-sanitizer according to directions cannot be over-emphasized. In order to avoid the cost of a dual-purpose product, some people add the quaternary to the washing powder which they happen to be using. Such a practise is a public health hazard because many ordinary cleaning agents, especially soaps, would inactivate the quaternary more or less, resulting in inadequate sanitation.

Detergent-sanitizers should be purchased only from reliable companies whose products are compounded on the basis of fundamental research work. Reliable companies are usually happy to submit samples to health departments for test in laboratory or in the field. Unfortunately, the introduction of new products is apt to be accompanied by fly-by-night organizations which compound their products in a hit-or-miss fashion.

Some of the earlier detergent-sanitizers on the market were effective sanitizers when fresh but lost a considerable part of their germicidal properties after six months storage. Such difficulties are now being eliminated, and manufacturers should be asked to submit test data on the shelf life of their particular products.

Since detergent-sanitizers are new products about which there is still much to be learned, it seems desirable that each prospective user should have the product tested, when diluted with the water ordinarily used. The germicidal tests made should not be the common phenol coefficient test but a test which simulates more closely practical working conditions. Such a test has been developed and used for some time in the dairy research laboratory, University of Massachusetts, and is very similar to the one recommended recently by the U. S. Public Health Service.

CONCLUSIONS

While detergent-sanitizers have not been perfected, they do appear promising enough to receive further consideration.

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(including MILK AND FOOD SANITATION)

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International Association of Milk and Food Sanitarians

(Association Organized 1911)

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ASSOCIATION NEWS

Wilster Honored by Oregon Dairy Manufacturers

During a dinner meeting held at Portland, Oregon, Dr. G. H. Wilster, Professor of Dairy Manufacturing, Oregon State College, was presented with a leather billfold containing the sum of $2600 as a gift from the Oregon dairy industry and allied industries. The money is to be used for a trip to Europe where Dr. Wilster will attend the World's Dairy Congress at Stockholm and then study dairy conditions in Sweden, Norway, Denmark, Holland, Great Britain, and Ireland.

The following statement was made by Mr. George Jacobsen, Chairman of the special committee of the Oregon Dairy Manufacturers' Association:

"With the acceptance of your thesis entitled 'The Vacreation Process in the Butter, Cheese, and Ice Cream Industries' by the World's Dairy Congress Committee for presentation this coming August at the World's Dairy Congress at Stockholm, Sweden, you have not only achieved great honor for yourself, but also for Oregon State College and the whole dairy industry of the State of Oregon.

"In view of this honor, and also because of your untiring efforts in helping to improve and raise the quality and standards of all dairy products in our state over the past twenty years, the industry at this time feels that it should not only honor you but materially assist you on your trip to and from Europe. Therefore, it is with great pleasure that I, at this time, can present to you, in behalf of the entire dairy and allied industries of this state, the sum of $2600 to be used by you at your pleasure on your trip to and from Europe."

Chicago Dairy Technology Society

Dr. L. B. Howard, head of the new Food Technology Department, University of Illinois, gave an interesting talk on "What's Happening in the Food Industry."

Dr. Howard said the trend is to larger food manufacturing establishments and away from individual units. Of the food consumed, 4/5 of it is processed. For years, processing of food has been an art. Now this art is giving way to a science.

Dr. Howard said studies in basic information were very important and very slow. He discussed some recent developments of importance to the food industry such as the low temperature evaporator, drying from the frozen state, monosodium glutamate, cotton-seed protein and converted rice which retains as much as 75 to 80 percent of the vitamins in the original rice.

Through research, Dr. Howard said food will be made more palatable, nutritious and economical. To achieve this, continuity of research is all important as research cannot be purchased on a package basis.

H. P. Smith
Recording Secretary

Russell L. Pollitt—1900–1949

Russell L. Pollitt, President of the Central Illinois Dairy Technology Society, passed away Sunday, May 22nd. at the Lake View Hospital in Danville, Illinois. Mr. Pollitt had been ill only a short time having undergone surgery a few weeks previously in Chicago.

At the time of his death, Mr. Pollitt was Manager of the Danville branch of Beatrice Foods. He was born August 11, 1900, at Germantown, Kentucky. He graduated from the University of Illinois in 1923 with a major in dairy manufacture. Besides the widow, he leaves one son, Gene, a student in the Danville High School.

Russell Pollitt was a man of excellent character. He was a leader in his church, active in civic work, took part in numerous industry affairs, and was considered an outstanding administrator by Beatrice officials. He has served as President of the Central Illinois Dairy Technology Society since January 1, 1949.

During the past year, Mr. Pollitt has served as President of the Illinois Milk Dealers Association. He was a member of the Danville Consistory, The American Legion, Danville Chamber of Commerce, Danville Planning Board, and was past senior Councilor of the Commercial Traveller's Association.

P. H. T.

Food Poisoning

(Continued from page 239)

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FEDERAL SECURITY AGENCY
U. S. Public Health Service
WASHINGTON 25, D. C.

May 19, 1949

To: All Regional Directors
Attn: Regional Medical Directors, PHS

Subject: Bactericides and detergent-sanitizers containing quaternary ammonium compounds.

In view of the frequent questions raised concerning the above subject by Regional Offices as well as state and local health officials and industry, the following information is presented.

The PHS Milk and Food Sanitation Advisory Board has recently approved by mail ballot the insertion of the following statement concerning quaternaries, based on the findings of the PHS Environmental Health Center, under Satisfactory Compliance of item 14r of the forthcoming revised milk code (PHB 220):

"Since the efficiency of the numerous quaternary ammonium bactericides on the market varies widely and is affected by the mineral content of the water in which they are used, it has not been possible as yet to establish standards of minimum concentrations effective for all compounds and under all conditions. The health officer should permit the use of only those quaternaries and only in those concentrations and contact periods which he has found by suitable test to be effective in the water to be used. In the absence of any reliable and rapid chemical test of the bactericidal efficiency of quaternaries, a suitable bacteriological procedure is recommended, such as that of Weber and Black (AJPH, Oct. 1948, p. 1405). The swab test is not considered suitable for this purpose at the present state of knowledge of quaternaries. It may eventually be possible to prepare a synthetic test water incorporating all interfering substances in such a standardized manner as to permit the testing of quaternaries in a central laboratory under conditions equivalent to those of actual use."

The above procedure is considered satisfactory for determining the bactericidal efficiency of quaternaries for use by milk plants and food establishments using the city water supply. The problem of testing the many compounds offered on the market against each dairy farm water supply and each private water supply used by food establishments presents practical difficulties the solution of which is not obvious at this time.

The statement issued a few months ago by the Land and Air Carrier Branch, Division of Sanitation, disapproving the use of quaternaries for utensil sanitization on interstate carriers was based largely on the fact that many different water supplies are used by the carriers, and there is at present no practical method of determining the bactericidal efficiency of all quaternaries against all of the different water supplies. A definite stand had to be taken by PHS because it is legally responsible for sanitation on interstate carriers.

In the case of detergent-sanitizers containing quaternaries, the problems involved are similar to those for quaternaries, as described above. In wash water the use of an effective detergent-sanitizer, in which the detergent is not incompatible with the sanitizer, will reduce the bacterial count of the wash water and of the utensils washed therein, thus reducing the bacterial load on the final bactericidal process. However, the use of detergent-sanitizers for single-stage washing and sanitizing, as recommended by certain manufacturers, is contrary to the accepted practice of separating the washing and the sanitizing processes. In the interest of accumulating further knowledge on the subject, however, health officers are justified in granting provisional permission for limited experimental use of single-stage detergent-sanitizers under carefully controlled conditions.

A. W. Fuchs, San. Engr. Dir.
Chief, Milk and Food Branch
Division of Sanitation

Position Open

THE WEST VIRGINIA STATE HEALTH DEPARTMENT WILL ACCEPT APPLICATIONS FOR THE FOLLOWING POSITIONS IN THE DIVISION OF SANITARY ENGINEERING TO BE FILLED JULY 1, 1949:

	Annual Salary Range
SANITARIAN	
Minimum requirements—College graduation	$2640–$3120
JUNIOR ENGINEER	
Minimum requirements—Graduation from an accredited four-year college or university with a major in Engineering	$2880–$3840

Possibility of future promotions

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W. Va. State Department of Health
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"DOCTOR JONES" SAYS— *

PAUL B. BROOKS, M.D.

"Alpha and Omega, the beginning and the end." That came to mind as I was reading some of these articles on Geriatrics—the care of the aged. The thing that struck me: the beginning and the end they're combined, at one and the same time, in a single personality.

Us humans, we're inclined to think of the young and the old as two different classes of people. "Poor old Gramp!", the teenager says, "Born forty years too soon," and Gramp: (I read this one) "Wouldn't it be terrible if we were born old and had to look forward to growing young, green and silly?"

But the size of it: young and old, seventeen and seventy, it's practically all in one. Each one of us: we're young to those that're older and old to those that're younger. Today we're young in years and, like a movie, one age period "fades in" on another and, before we know it, we're old. Yes, us young folks, we need to realize that "the aged": that's *us* the day after tomorrow. Then this movement to provide for the health, comfort and happiness of old people—it'll really get moving.

Age—it isn't mainly a matter of how many birthdays we've had. A white-haired woman that used to be a neighbor of ours, if anyone was sick she was the first on deck; most church or community affairs, she had a hand in 'em. The little girl from across the road—one day she was looking at her, sort of puzzled. Finally, "Say, Mis' Merrifield", she said, "are you young or old?" Well, in years she was seventy, in energy and capability forty and in spirit twenty.

No, it's a question of how well our minds and bodies work and how well we can adapt ourselves to what we've got to do—or want to do. As a prize-fighter Joe Lewis, at thirty-odd, is old; as international statesmen General Smuts and Bernard Baruch, at more'n double his age, are young. We need a better system of establishing age, I guess, than just counting birthdays. And maybe we'd better get at it. You can't judge Father Time's activity by his whiskers.

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