MICROBIOLOGICAL STANDARDS FOR FOODS

Microbiological testing for pathogens and indicator micro-organisms in food, in the factory, on the farm, or at the market, is only one phase of the process of preventing food poisoning. Useful and important in themselves, tests for microbial content of foods are futile if they are not accompanied by sanitation, adequate reporting and investigation, and public education. Microbiological standards for food, be they official, voluntary, or administrative, have been effective in promoting sanitation in many phases of the food industry. Nevertheless, there is a need for research, aimed at especially suspect foods, directed to specific organisms, processes, and stages of production, so as to develop defensible, attainable, and desirable standards, testing methods, and tolerances under authoritative auspices, as a guide to industry and as a protection for the consumer.

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These comments were typical of the statements expressed by distinguished scientists, representing research institutions, regulatory agencies, and food industries of North America and Europe, at a conference on microbiological standards for foods, June 8–9, 1960, Washington, D.C., called by the Division of Medical Sciences of the National Academy of Sciences-National Research Council. The division's committee on sanitary engineering and environment joined forces with its committee on medical microbiology to organize the meeting, under the chairmanship of Prof. Walter D. Tiedeman, resident lecturer at the University of Michigan, in association with Dr. Morris Shiffman, Department of Public Health, Philadelphia.

The conferees unanimously recommended that the NAS–NRC explore ways and means of furthering objectives on which the session was agreed.

The conference addressed itself to five questions posed by the chairman:

1. Are microbiological standards for foods necessary and desirable?
2. To what classes of food products should standards be applied?
3. What microbiological tests are applicable to foods?
4. How should limits be determined?
5. What practical results may be expected from the application of reasonable microbiological standards?

Along with the discussion of these issues, the conferees heard and participated in a series of auxiliary discussions so comprehensive that some excursion into questions of nutrition, palatability, spoilage, and chemical contamination was unavoidable.

The Issues

1. The necessity and desirability of microbiological standards proved to be beyond debate. It was agreed that some standards of microbiological quality are always implicit. It was agreed that explicit standards generally have

had desirable effects, although specific standards are not always appropriate.

To develop and define standard limits, methods, and procedures, all considered to be desirable, the conferees urged considerable further education, study, and experience. They asserted there is an obvious need to build upon current standards. Food plant inspection was agreed to be a necessary and important phase of administering standards.

2. Classification of food products for application of standards was found to depend on a variety of factors. The ingredients and method of preparation, according to one system of classification, would emphasize the possibilities of contamination. Another factor in classification is experience with foods which have demonstrated a considerable hazard and which are amenable to regulation. It was agreed that an obligation rested with regulatory authorities to deal with immediate and obvious challenges presented by experience. The discussion brought out that few foods are completely secure from hazards in all circumstances.

3. The most earnest discussion as to the selection of microbiological tests concerned use of the coliform count. The experience of New York City suggested that this test was not any more effective as an indicator of contamination than the standard plate count, when such counts were high. Others proposed that a test for *Escherichia coli* be applied, as a more certain indicator of the presence and growth of enteric pathogens, when standard plate counts are low.

A single standard test for all foods had no champions. Although the standard plate count was agreed to have practical value as a measure of microbiological growth, it was agreed that the variety of foods, sampling methods, processes, and flora, and the possible presence of toxins without organisms, required a selection of tests and standards appropriate to the hazards.

4. The conferees discussed methods of determining limits as a critical challenge. Arbitrary official limits, while effective, were felt by several to pose an occasionally unreasonable threat to commerce. The zero requirements for coliforms in frozen foods was asserted to be impractical. It was agreed that there was far too little epidemiological knowledge at present on which to base precise limits in all circumstances. By implication, empirical limits, set administratively rather than legally, with the support of continuing studies, seemed to be a favored course. It was suggested also that limits be based on the numbers and types of microorganisms attainable under good practice.

Numerical rather than qualitative standards, as a desirable proposition, had no opposition. The practical difficulties were found to lie in determining what quantity of growth is hazardous or indicative of improper storage or preparation in a given test or situation. There is also the need to determine quantitatively the presence of specific pathogens such as staphylococci and salmonellae. A further consideration was the current lack of sufficient personnel and laboratories to perform as many tests as might seem statistically necessary.

5. The immediate practical achievement of the conference was to agree on the need to seek support through the NAS–NRC, and its working committees, for continuing and expanding efforts to develop and apply standards. The practical value of such standards were believed to be foreshadowed by past achievements. However, none felt that microbiological standards by themselves would suffice to protect consumers from infection, poison, or spoilage. The gains in public protection, it was agreed, would require further advances in the knowledge and practice of sanitation by professionals and technicians, commercial interests, and consumers. There was no issue between realists and perfectionists: all accepted the virtue of directing attention toward specific situations where microbiological standards seem most likely to improve the safety and quality of mass-market foods.

None of the questions posed was solved specifically or absolutely. For such answers, the conference looked forward to specific studies.

Conferees' Comments

Dr. Robert F. Korns, deputy health commissioner of New York, reminded the conference that in these days of mass production and international distribution, with long-term refrigerated storage, the classical point-source outbreak of food poisoning is no longer typical.

Instead, the epidemiologist confronts individual illnesses with no common location or period, even though they have a common source. For example, he cited a collection of cases of typhoid fever, identified as type E1, which occurred chiefly in adolescent males in half a dozen States, with 11 in New York alone. Although candy was suspected, the best efforts of a crew of epidemiologists failed to identify the source.

Other complications in the use of microbiological tests, Korns mentioned, were the presence of toxins without viable organisms, as in the staphylococcal enterotoxin which occurred in dry powdered milk in Puerto Rico, the possible viability of viruses or rickettsia in animal food products, and the presence of carcinogenic or toxic chemicals. He also observed that while foods may characteristically produce a high plate count, it is advisable to relate the application of microbiological standards to those foods and situations known to produce significant amounts of disease rather than to apply such measures routinely to all classes of foods. He expressed a faint hope that improvements in surveillance and reporting would strengthen the case for specific microbiological standards.

In this same precautionary vein, Dr. L. Joe Berry, speaking for the Committee on Medical Microbiology, mentioned the phenomenon of mixed infections, citing experiments in which germ-free animals resisted infection by *Entamoeba histolytica* until they were also exposed to *Escherichia coli.* He also cited a reversed relationship, reported by Schaedler and Dubos to the Society of American Bacteriologists in May 1960, in which pathogen-free mice were found more susceptible than standard Swiss mice to *Mycobacterium tuberculosis*, *Klebsiella pneumoniae*, and *Staphylococcus aureus* until inoculated with a specific strain of *E. coli* from the intestines of the Swiss mice.

Allowing for all such limitations and a few more, Dr. D. A. A. Mossel, Central Institute for Nutrition and Food Research, Utrecht, The Netherlands, asserted that microbiological tests have demonstrated their value in several respects, as a supplement to education, sanitation, and inspection. He cited microbiological studies which found pathogens in raw foods which would otherwise have been unsuspected and undetected. Other uses of the tests, he noted, are to provide a check upon careless, erratic, or too congenial inspections; to offer final evidence that a given process is adequate and proper; and to establish goals for the improvement of sanitation in food.

Mossel urged, however, that standards of tolerance be specifically adapted to each separate food in a realistic way, that they be expressed numerically, that they pertain to specific organisms, using valid nomenclature, and that they be accompanied at all times by satisfactory standard methods of examination.

Speaking on the kinds of foods which might be subject to microbiological standards, Dr. Glenn G. Slocum, Food and Drug Administration, cited Thatcher's listing of such factors as the nature of foods; the method of processing, handling, and distribution; the opportunity for contamination, multiplication, or toxin formation; and the antimicrobial treatment, such as cooking. These factors, he said, focus attention on nonsterile foods consumed without adequate treatment.

Specifically, he mentioned foods which embrace all the factors: cream-filled or custard-filled bakery products, high protein foods, egg and potato salads, and products widely distributed for sale "more or less" under refrigeration. At the same time, he observed that the very perishability of such products limits the value of tolerance standards in removing them from the market, although the microbiological tests, he said, would lead to correction of errors in the chain of distribution. Frozen and dehydrated foods combine most of the factors except that opportunity for growth of microorganisms is limited by the means of preservation and distribution.

He expressed less concern with fresh or raw foods and canned foods as general classes, but in each category he cited specific instances in which apparent hazards might be decreased through microbiological studies.

Slocum emphasized, however, that neither he nor the Food and Drug Administration specifically advocates microbiological standards for any class of foods at this time. As he observed in his opening remarks, his agency is already vested by law with responsibility for protecting the public from food which contains a poisonous or deleterious substance, which is filthy or de-

composed, or which is prepared, packed, or held under insanitary conditions.

In the discussion, there was general agreement with a view, expressed by Dr. F. S. Thatcher, Department of National Health and Welfare, Canada, that efforts to develop standards should be directed primarily to situations which give evidence of the need and which offer an opportunity for practical achievement.

With respect to prevention, while it was conceded that a factory may supply food free of contamination, it was agreed that recontamination is not unusual if not inevitable under common circumstances, such as those cited by Col. John Rizzolo, Armed Forces Epidemiological Board, in reference to experiences of expeditionary forces in places where sanitation is unknown.

As to methods of determining microbiological standards for food, Prof. Aage Jepsen, Royal Veterinary and Agricultural College, Denmark, recommended a balance between the desirable and attainable. Emphasizing that foods must be appraised according to their specific nature and use, he described four categories, each requiring different consideration. High-temperature heat-treated hermetically packed foods, such as canned meats, being moist and lacking inhibitors such as salt, he said, may be vulnerable to microbial growth. Cultures from preincubated samples of such foods, he suggested, should prove sterile or yield only a scanty growth of organisms incapable of multiplication in the container.

Low-temperature heat-treated hermetically packed foods, such as cured hams, he said, containing salt and nitrite, allow only a restricted growth of salt-tolerant organisms. In these conditions, he said, gram-negative rods, fungi, and clostridia should be absent, and fecal streptococci and lactobacilli if present at all should be insignificant. The total count of aerobic organisms, he suggested, should be less than 10,000/gm., usually much less.

Low-temperature heat-treated nonhermetically packed foods, he noted, may be subject to recontamination, and standards of tolerance would be related to the probability of recontamination and the subsequent methods of storage and processing. In any event, he recommended that salmonellae should be absent.

Non-heat-treated salted or chemically preserved foods, such as anchovies, he said, carry a microbial population whose total numbers bear little relation to keeping quality. However, he thought it might be useful to test them for pathogenic or toxinogenic organisms.

Fresh or raw frozen foods, he said, develop a bacterial count which may be related to temperature as well as to storage; but whatever the cause, a heavy microbial load in perishable foods indicates spoilage. He suggested raw frozen foods and raw shellfish as candidates for standards similar to those suitable for low-temperature heat-treated nonhermetically packed foods.

Speaking to the adequacy of microbiological standards as indicators of the sanitary conditions of food processing, Thatcher emphasized that the chief hazard of contamination is associated with the food handler, in the factory as well as in the kitchen, but he also mentioned defective design, construction, or maintenance of equipment or plant, direct contamination by rodents or insects, time-temperature factors in processing, and the quality of water used in the plant.

Although Canada uses the standard plate count, fecal indicators, and staphylococci tests chiefly as a check on plant sanitation, Thatcher recommended that the test for *E. coli* be favored as more likely to demonstrate the presence of fecal organisms, including enteric viruses. Because of their ubiquity, he questioned the merit of a zero requirement for staphylococci, but said he was ready to revise his views if foods become a vehicle for antibiotic-resistant strains of a virulent type.

Thatcher suggested that the standard plate count itself might serve as an indicator of defects in the chain of food production but indicated that he would also like to see a rapid and efficient method for detecting salmonellae.

The value of microbiological standards in promoting sanitary conditions in industrial food products, he stated, has been demonstrated not only with dairy products but with gelatin, bone meal, raw oysters, and crabmeat. While frozen foods have improved considerably in the absence of specific standards, he felt that the industry was spurred by the prospect of standards, as well as by its business interest.

While he did not imply that tolerance standards automatically guarantee safety in food, he said the presumption of safety favors foods that meet such standards. Also he noted that microbiological standards tend to encourage the selection of high-grade raw materials and their careful management. The coding of food lots, he observed, helps to isolate and recover foods found by microbiological examination to be dangerous. The opportunities for collaboration between the regulators and the regulated, he suggested, warrant earnest study.

In a program of action outlined for industry and government, Thatcher included factfinding and education in relation to new foods; standards for familiar foods offering experience with hazards or spoilage; development of industrial codes; enforcement of standards; education of food handlers, including transport workers, restaurant managers, and housewives; and development by industrial associations of mobile teams of "troubleshooters."

The tests which are favored, and their limitations, were discussed by Dr. Harry E. Goresline, Quartermaster Food and Container Institute for the Armed Forces, who, like Mossel, put special emphasis on the standardization of methods of examination, as essential to standards of tolerance. He also asserted that standards of operation in the food industry, determined by surveys of actual practices, should be no less important than standards of microbiological quality.

With respect to the former point, he cited studies which demonstrated the wide range of bacterial counts that resulted from slight differences in temperatures, media (presumably identical), sampling, or procedure. Before determining microbiological tolerances, therefore, he asserted that it is desirable to obtain data collected by standardized procedures. The next step he recommended was to limit requirements of the standards to attributes necessary for control and to microbes of true significance. Third, he proposed universal adherence to standard methodology, from sampling to reporting. Finally, he suggested that a range of counts, rather than a specific maximum, would be best for tolerance limits, except for certain pathogens which should be kept to the lowest level possible, in proportion to the hazard.

Specifically, he urged consideration of the "Recommended Methods for the Microbiological Examination of Foods," published by the American Public Health Association, as a step toward establishment and acceptance of standards methods.

Conceding that standards seem a worrisome burden to some and a necessity to others, he believed a meeting of the minds was possible.

With regard to the relation between microbiological standards and component product control, Dr. Millard Gunderson, associate director of bacteriological research for Campbell Foods, devoted his statement mainly to the special characteristics of frozen foods which, it was generally agreed, have in general improved in sanitary quality in the past 10 years in the absence of specific standards. The industry, he said, finds fewer public health hazards in the microbial population of frozen foods than threats of waste or spoilage. Each package, he said, is a micro-climate which, in fluctuating temperatures, may develop growths of mold. Having given attention to the proper selection, storing, and processing of frozen foods, he said, it is still necessary to follow through to assure storage at zero temperatures by the vendor and the consumer. As evidence of the effectiveness of sanitary controls, he offered data indicating the range of and average microbial counts in frozen food samples taken from retailers. He emphasized that biological tests serve mainly, after the fact, to assure the operator that sanitation processes are adequate. Under practical working conditions, he indicated it was difficult to pinpoint variations in the line which might produce sporadic samples with high microbial counts.

Dr. G. M. Dack, University, of Chicago, opened with the statement: "No simple microbiological standards can be applied to all classes of food. In the application of microbiological standards, careful thought should be given to the quality of the raw ingredients entering the product, how the product is made and packaged, and conditions of time and temperature of storage from the time of production to the time it reaches the consumer. Of importance is whether the end product, in any stage of processing, provides conditions for the multiplication of food poisoning micro-organisms."

He proceeded to draw upon his experience with a number of foods to illustrate the variety of conditions for the multiplication of food poisoning organisms. He noted that when heating destroys the competitors of *Clostridium botulinum* in cheese spreads, the organism may grow and emit toxin. A similar possibility was found in connection with canned hams, but as 5 million canned hams have been sold with no case of botulism, the hazard apparently does not exist in American packing houses.

Dack attributed outbreaks due to staphylococcal enterotoxin in part to the fact that the enterotoxin is resistant to the usual heat treatments. No such hazard is found in precooked frozen foods because they are cooked at 350° F. for 40 minutes before serving. The main source of such food poisoning, he said, is the food handler with pyogenic lesions, where contamination is followed by time and temperature sufficient to build up toxin. It takes millions of staphylococci, he said, to produce enough toxin to cause illness.

Protection from salmonellae in poultry and meat products, he said, is provided as a rule by the fact that the products are cooked before serving. However, Dack mentioned that one of the possibilities in the dissemination of salmonellosis is the widespread use of frozen and dried eggs in food processing in this country. For example, in an angel food cake mix, picked up in the markets in January 1960, 15,000 *Salmonella montevideo* organisms were recovered per gram of the egg white mix in the product. Since this egg white powder is diluted approximately 1:3 with sugar, this would represent approximately 50,000 *S. montevideo* per gram of the dried egg. Products of this sort may have sufficient salmonellae to cause illnesses in children eating cake batter prior to baking. A suggestive example was an outbreak of *Salmonella reading* infection, involving 325 widely distributed cases, mostly in small children. The source of this outbreak, however, was not established. The cake mix manufacturers were apprised of this condition, and they have placed microbial specifications on dried egg white. With these self-imposed standards by industry, salmonellosis hazards are reduced.

During the discussion, Jepsen observed that heating liquid egg white to 56° C. for 3 minutes appeared to be effective, even if all salmonellae were not destroyed.

Dack also mentioned the hazard of *Bacillus cereus*, a soil organism natural to cereal products, which was responsible for a large number of illnesses in Norway among those who ate a commercial vanilla pudding. After cooking, it had been left at a warm temperature for several hours, permitting surviving spores to grow.

In conclusion, he recommended labels give specific directions for refrigeration and cooking, to reduce hazards of food poisoning.

Dr. Leon Buchbinder, New York City Health Department, referring to the value of microbiological standards in improving the safety of water and milk, noted that the plate count standard for milk had been reduced from 500,000/ml. in the 1900's to 30,000/ml. currently. However, he pointed out that milk and water management are distinguished from foods in general by relatively closed processing and distribution systems and a limited number of processing plants and channels of distribution. Food management is handicapped further, he added, by the ubiquity of organisms that cause food poisoning, apathy of most of those who should be concerned, and the apparent assumption by many health authorities that food poisoning is well controlled.

He offered as a guess the estimate that there are 500,000 cases of food poisoning in the United States annually. With respect to salmonellosis alone, Slocum mentioned a sevenfold increase in reported cases nationally between 1950 and 1957. A similar gain, he said, was reported in Massachusetts, which has a long record of reporting such incidents.

Speaking of practical experience in a city laboratory with microbiological standards, Buchbinder stated that a frankly arbitrary tolerance had been effective in improving sanitation of specific foods notoriously associated with outbreaks.

The methods used include the plate count, coliform count, *S. aureus* count, enterococcus count, and *Salmonella* isolation. Isolated staphylococci are phage tested. A plate count above 750,000/gm. for staphylococci and enterococci in foods associated with an outbreak warrants a test for pathogens. Phage typing, said

Buchbinder, has implicated foods with low counts of staphylococci. Buchbinder expressed also the view that the standard plate count discounted the need for a coliform count. Jepsen and Slocum, in discussion, stated that coliform determinations provide information not revealed by the plate count alone.

In addition to testing foods implicated in outbreaks, the laboratory examines "check-up" foods associated with the implicated foods, which are not usually available. Other tests are performed on samples taken in general surveys of foods considered vulnerable.

The surveys are used mainly for preventive purposes, as in connection with frozen precooked poultry products. Of 17 samples from one manufacturer, 13 were found to have counts of 1 million or more.

At about the same time, the department surveyed custard-filled items from 65 wholesale bakeries, establishing a standard plate count not to exceed 100,000/gm., and a coliform standard of no more than 10/gm. More than two-thirds of the bakeries flunked the test. Some of these improved their procedures and the count declined. The others made no improvement and were requested to discontinue the line. Several hundred retail bakeries have been examined annually on the same basis in recent years.

Standards for fresh crabmeat established by New York City (plate count not to exceed 100,000/gm., enterococcus, no more than 1,000/gm., staphylococcus and coliform, no more than 100/gm.) touched off a broad reform in packing practices on the eastern seaboard. The percentage of samples failing the test declined from 63 in 1953 to 37 in 1956, about the current level. Buchbinder also reported experiences with skinned, precooked, packaged, ready-to-eat beef tongue and with frozen, breaded, codfish cakes, demonstrating the value of microbial tests in supporting the efforts of sanitarians.

In conclusion, Buchbinder referred to the requirements applied to food purchased by the Armed Forces as evidence of the contribution of microbiological standards to the prevention of food poisoning.

Dr. John Silliker, Swift and Company, described in detail variations in food, flora, and processing which affect microbiological standards. He demonstrated several instances in which microbiological standards at a given stage of processing by themselves are meaningless with respect to safety or keeping quality of food. He emphasized consideration of the quality of raw materials, the treatments used, and the different microbial characteristics of individual components of a food product.

The need for administrative arrangements which would enable professional societies, trade associations, enforcement agencies, and others to work together effectively to develop mutually acceptable standards for the protection of the public was advanced by Dr. Keith H. Lewis, Public Health Service. Referring to the various efforts current, he commented that participation was associated with difficulties in obtaining timely action and continuity. He proposed that another meeting concern itself specifically with developing a workable plan, including mechanisms for coordination and financial support.

Lewis also suggested that specificity is an inherent characteristic of microbiological standards for foods, to judge by experience with water, shellfish, and dairy products. Methods and criteria, he said, must be appropriate to specific microflora, various potential contaminants, chemical and physical conditions, processing techniques, and distribution practices, if standards are to offer genuine protection. Although general standards for dissimilar foods may be expedient, he said, they are not adequate.

In summarizing the discussion, Goresline observed, "There was the feeling that within the framework of the food industry, the distribution and regulatory fields, something should be done to improve the sanitary quality and handling of food products. There was praise for the improvements that have taken place in the last few years, but with it an appeal to continue the rise. There were suggestions to broaden the areas of concern from the public health standpoint to include the viruses and chemicals. . . .

"Several speakers repeated the theme of the relationship of raw product quality and practice of good handling to the sanitation and quality of food offered the consumer. There has been a feeling that most food poisoning outbreaks could have been prevented if good prac-

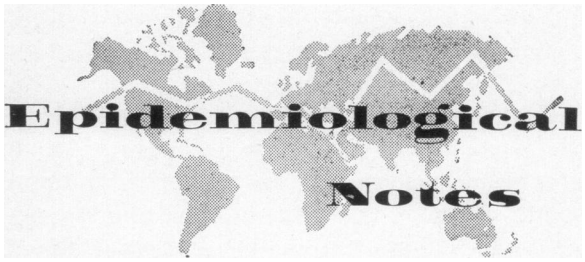
tices had been employed. This indicated a great need for a more effective educational program aimed at every segment of the chain from producer to consumer. It was demonstrated that a motivated commercial producer of food products can through a rigid quality control program, and training of employees, consistently put out products of good sanitary quality. There is a need to spread this motivation.

"It was pointed out that regulations and laws spell out certain standards without indicating them as such. Experiences with standards have been good for the most part, but I heard no one advocate them for all products or for food in general. It was pointed out that there were different classes or types of food, each with its own needs, uses, and even different flora."

He pointed out that the conference favored standards with a definite use, but recognized that such functions might be performed by other methods. Difficulties in administering and interpreting standards were linked to the methodology and techniques employed. The conference inferred therefore, he suggested, that thorough investigation is a necessary preliminary to the establishment of standards.

He praised the conference for its coverage, the opportunity to exchange ideas, and to improve mutual understanding of the factors relating to food safety.

The conferees in general agreed that there were always implicit goals of microbiological quality which influence both the management and regulation of food processing.



Retrolental Fibroplasia

The rate of decline in incidence of retrolental fibroplasia is indicated by figures obtained by the National Society for the Prevention of Blindness from seven States. Hyperoxia was associated with retrolental fibroplasia by K. Campbell, in the *Medical Journal of Australia* in 1951. Confirmation of this hypothesis was prominently published in 1953 and 1954; publications included newspaper feature stories and an article in the *Saturday Evening Post.*

States reporting the cases totaled here are California, Connecticut, Kansas, Massachusetts, New Jersey, New York, and North Carolina. Reporting in 1957 was incomplete, and only 5 States reported in 1958. Following are the reported new cases of blindness caused by retrolental fibroplasia:

Year	*New cases*
1950	278
1951	363
1952	464
1953	442
1954	170
1955	62
1956	35
1957	10
1958	7

Despite the abrupt decline in incidence, it is evident that to provide maximum protection against blindness associated with retrolental fibroplasia, doctors, nurses, and hospital administrators need to adhere vigilantly to procedures recommended for administration of oxygen to premature infants.

An annotated bibliography on the relationship of oxygen therapy to retrolental fibroplasia is available from the National Society for the Prevention of Blindness, 1790 Broadway, New York 19, N.Y.