As we look at the past in terms of present knowledge about our environment, we recognize that technological advances have greatly changed man’s living conditions. Applications of research on the farms, the highways, the airways, and in homes, factories, and offices have greatly reduced the physical effort required of the individual to sustain life, and, at the same time, have increased the amount and variety of essential goods, conveniences, and luxuries. In our eagerness to take advantage of these developments, we have been little concerned until recently about their subtle effects on health. Whether we regard the changing environment with apprehension, or with enthusiasm, there is nothing to suggest that this trend will be reversed. On the contrary, all indications point to more rapid changes in the future. We are already encountering almost daily innovations and modifications of our surroundings that may have direct effect upon physical vigor, mental alertness, longevity, and susceptibility to degenerative diseases. These changes have occurred in all fields of endeavor, and the food field has by no means been neglected. In no facet of his environment has man wrought more dramatic and important changes than in feeding the urban population. The traditional simplicity of food preparation in the home from staples and local produce is being replaced rapidly by complex new systems of food production, manufacturing, distribution, and serving, which now represent an 80-billion dollar segment of our economy (13).

The major trend in the food field today is toward centralized processing and widespread distribution of commercially prepared convenience foods, which minimizes or eliminates culinary work in the preparation of meals. The ready availability and general acceptance of these products, including foods from foreign sources, has further complicated the already difficult task of assessing the sanitary quality of foods at the State and local levels.

This trend has not developed overnight, but has been brought about by research and development within the food industry and by the changing socio-economic patterns of our population. The development of technical criteria for public health evaluation of foods has not kept pace fully with industrial development, but many research findings have been utilized for this purpose. Much remains to be done which we shall touch upon later, but let us explore first where research findings have already been applied successfully to ongoing programs, and then see if we can identify new areas where existing knowledge may be applied.

Our primary objective in food protection programs is the prevention of outbreaks of foodborne illness. One practical method of preventing such outbreaks is the application of temperatures that will inhibit or destroy the causative organisms in perishable foods. For many years, 50°F was regarded as an acceptable upper limit for refrigeration of perishable foods. These limits were regarded as safe temperatures for the refrigerated storage of such food and were based upon data which indicated that 50°F was sufficient to prevent the growth and toxin formation by Clostridium botulinum types A and B. Until recently, very little information was available which would give a true picture of the time-temperature relationship needed to effectively control or kill other organisms that are frequently associated with foodborne disease outbreaks.

Research in this area has demonstrated that a temperature lower than 50°F is necessary to effectively control the growth of salmonellae and staphylococci in foods held for extended periods of time. These research findings (2) have been utilized in the development of standards and guides incorporating the recommendation that all potentially hazardous foods be held at 45°F or below, and have further stimulated industry and food equipment manufacturers to design equipment which will assure that these temperatures can be met. The popularity of precooked, chilled products, the increased use of automatic vending machines for dispensing perishable meals, and the extended storage of convenience foods, have complicated the time-temperature control problems and made the general application of this information very important.

A relatively new practice in the preparation of meals for service aboard airplanes, is to precook and freeze the meals for defrosting and serving in flight.

Utilization of Research in the Operation of Food Protection Programs

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Since the meals may be prepared considerably in advance of being placed aboard the plane, and may be subject to wide temperature variations, it is important that some method be employed which will indicate any major temperature variations within the package. In other words, a device is needed which will operate continuously and will indicate whether the temperature of the food has exceeded a predetermined level. Several devices that depend upon temperature levels to cause a color change have been developed through research by industry, and one is now in experimental use by an airline company. With such a device the stewardess could inspect the packages of meals and instantly be assured that the meals coming aboard her plane have been stored at the proper temperature since being prepared. She can, therefore, reject those that show too great a temperature fluctuation during storage.

Even though such devices have not gained widespread acceptance in the frozen food industry, they do offer a method to monitor the temperature of frozen foods which will assure the consumer of a product that has been properly stored while being held in the frozen state.

Assessment of the sanitary quality of food presently depends primarily on visual inspection of the environmental conditions under which food is prepared or served. In light of the changing technology which permits food to be prepared by centralized processing, this method cannot always be relied upon to assure the consumer that the food is safe and wholesome at the point of final preparation for service. Additional laboratory examinations of vulnerable commercial products for potentially hazardous microbiological and chemical contaminants may be necessary to minimize the risk of serious outbreaks of staphylococcal food poisoning, salmonellosis, or other common foodborne diseases. Recent developments in methodology and instrumentation have made feasible the examination of selected food items for compliance with specific microbiological and chemical criteria which are indicative of sanitary quality. It is only a matter of time until research produces simple tests that can be applied routinely, with appropriate modifications, to a wide range of food items.

Experience indicates that in order for the public health laboratory to lend reliable assistance to the operating food protection program, a detailed analysis of food involved in outbreaks of gastroenteritis is necessary (1). In this regard, a comparative review and manual of methods and media for detection of pathogenic and indicator bacteria in foods has recently been published by the Public Health Service (14). This manual highlights some of the problems encountered in the microbiological examination of foods and presents bacteriological methods that are applicable to samples of food implicated in disease outbreaks or collected for survey purposes. The methods outlined are currently being used with success in PHS Laboratories, and their use by other public health laboratories may be expected to improve the detection of bacterial agents of foodborne diseases. Although the methods in this manual undoubtedly can be improved by further research, they are regarded as sufficiently useful to serve as reference procedures for the comparative evaluation of other methods.

Knowledge that the laboratory can, in fact, provide definitive information about causes of foodborne illness will no doubt induce persons with knowledge of suspected or proven outbreaks to notify appropriate officials so that laboratory and field investigations can be undertaken to elucidate circumstances surrounding the outbreaks and the control measures needed to prevent further trouble.

The accelerating rate of research utilization by the food industries accentuates the problem of informing personnel in operating food protection programs about recent technological changes and their public health implications. Of necessity, new methods must be employed to disseminate this information quickly. In addition to the development of specialized training courses and seminars, some organizations are beginning to use programmed instruction, closed circuit television, recordings that can be distributed by mail, telephone conferences, and other devices which accelerate communication and increase the efficiency of instruction.

The results of one research program can and do stimulate research by others on the same problem. In the field of microbiology, several investigators are working on the important problem of staphylococcal food poisoning. Their efforts have resulted in the purification of one toxic protein and partial purification of others, so that specific serological identification of at least two types of enterotoxin is now possible in food extracts. Steps are being taken to develop additional type-specific antisera and to make them available in other laboratories. When completed, these studies will constitute an important advance in food protection by providing a sensitive method for detection of staphylococcal enterotoxins without resorting to the use of human volunteers, primates, or cats (9).

Other examples of recent improvement in laboratory methodology for food protection include the development of simplified chemical procedures for analysis of radioactive fallout in foods, a differential test for reactivation of phosphatase in pasteurized dairy products, chromatographic detection of pesticide residues in foods and drinking water, standardization of the bioassay for paralytic shellfish poison, and develop-
ment of selective methods for the isolation and identification of foodborne pathogens such as Clostridium perfringens or Staphylococcus aureus. These research findings are continually being made available for application in food protection programs through technical publications and laboratory training courses sponsored by the Public Health Service as well as other organizations. There is, however, a substantial lag in adoption of new methods because of the natural reluctance of some individuals to accept changes as well as the difficulties of getting the necessary fiscal and administrative support. In our opinion the food protection organizations of State and local government, as well as industry, need to participate more actively in the evaluation and uniform application of new procedures.

It has long been suspected that the reporting of foodborne disease outbreaks is far from complete. There are many reasons why this may be true, but the Salmonella Surveillance Reports (17), which were started by the PHS Communicable Disease Center in 1962, are an excellent example of improved reporting in response to a cooperative mechanism provided by the epidemiologist to solicit information from other investigators such as bacteriologists, physicians, and veterinarians throughout the country. This is a good beginning for one important group of disease organisms that might well be extended in principle, to other areas of food protection. These efforts would help the participants to better understand their local problems and would stimulate them to find and report more suspected outbreaks, thereby establishing a basis for further investigation and corrective action.

Research findings have resulted in multilateral benefits to all concerned in food protection, from the producer to the manufacturer of food processing equipment, to the official agencies, and to the consumer.

The consumer has profited greatly because of the protection built into health-related equipment and products by industry based on research findings. In addition, official agencies have been appreciably benefited by industry's observance of acceptable standards and practices, and industry has experienced improved stability, provided by the assurance of sound, practical, and uniform standards, program guides, and recommended ordinances and codes which industry itself had an opportunity to help develop.

The primary purpose of food protection is, of course, to prevent unsafe foods from reaching the consumer; however, acute illness represents but one facet of the total problem. To this should be added the possibility of subacute or chronic effects from repeated exposure to chemicals or microorganisms that do not produce immediate responses in the individual. Such substances may be introduced at different stages of the food chain; e.g., during production, processing, storage, and preparation for serving. Study of the accumulative effects from repeated exposure to small amounts of food contaminants has only begun, but animal experiments suggest they may influence growth rate, longevity, and other physiological processes that influence the physical vigor and mental attitudes of the individual.

The foregoing is one of many problems that need further investigation. To cope effectively with the public health problems associated with the changing food industry, responsible agencies at all levels of government and the total food industry must place significantly more emphasis on food protection programs. Perhaps the magnitude of the work to be done can be best illustrated by mentioning some of the broad areas of concern to industry and the agencies responsible for the development and maintenance of food protection programs.

Since our basic concern is the prevention of foodborne disease, there must be developed new and improved methods for the recognition, investigation, and reporting of foodborne outbreaks. Such tools would permit better definition of the health hazards with which we are confronted today and allow better direction of a concerted attack on those problems.

Changing technology has taken a large part of the production of food away from strictly local control and increased the importance of establishing broad, nationally accepted criteria which will assure us that food has been produced, processed, stored, and distributed under acceptable standards. This will require a new look at present food sanitation practices and the operating programs designed to implement them. For the most part, many such existing programs and practices were developed before World War II and have not kept pace with the technological or socioeconomic changes.

Since research findings are valuable only to the extent to which they are utilized in the day-to-day operation of the protection of food by the industry and regulatory agencies, emphasis should be given to educational and training programs which will provide personnel at all levels of concern in the food field with a basic knowledge of the principles of sanitation and the new developments to which they must be applied. Industry and official agencies must share in the responsibility for such programs. One method which might be considered for this purpose is programmed instruction. This educational tool, in its various forms (12, 15), is gaining increased acceptance in our schools and industries as a teaching method and could be utilized in the teaching of principles of sanitation to food industry personnel. In addition, educational seminars, workshops, conferences, etc., which will keep food protection pro-
gram personnel abreast of up-to-date food protection measures, must be instituted on a wider scale than is now available.

Substantial information has been acquired through past research in food technology; however, it is essential that we continue to extend our basic knowledge about health hazards associated with foods. In addition to studying the individual constituents and contaminants of food, work is needed on the interactions of foods with other environmental factors in order to understand the impact of complex environmental situations on human health.

As yet, not all causes of foodborne disease are well known. Recent research suggests that the aflatoxins of Aspergillus flavus (5, 8, 10, 19) the enteric viruses (4, 6, 7), enteropathogenic E. coli (16), and other (18, 11) foodborne microorganisms may cause illnesses that have not previously been considered foodborne. We also lack the basis for assessing the health effects of numerous foreign chemicals in food (3). Quantities that caused acute illness can, of course, be judged hazardous, but lesser amounts of many substances in use today cannot be properly evaluated until more is known about these compounds when taken into the body.

In the past 20 years man has, through technological applications, brought about greater modification of his environment than he had in the previous 100 years. The industrial research and developments which assisted in bringing this change about, have been at least as prominent in the field of food technology as they have in other fields. Although the United States probably has today the most plentiful and varied food supply on earth, the means to protect the public from unsafe innovations has not kept pace with industrial developments. Each of us who is responsible for food safety, must cooperatively strive for extension of our knowledge, through research and education, to provide methods of food protection that can be effectively applied to improve the consumer's health and the industry's good reputation.

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