MEAT MICROBIOLOGY
AS SEEN FROM A GOVERNMENT LABORATORY

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When Chairman Greenberg enlisted my admittedly willing service to prepare this address, he established some general guides for my approach to the subject which I think you ought to be aware of. He said that in asking me to express the government view he was asking, not so much for an expression of a regulatory philosophy, as a consumer philosophy. Hence, I have changed the title to read, "Meat Microbiology, as Seen from a Government Laboratory". Those who know me, and that includes most of my audience, will know without any fresh affirmation on my part that I will express not the views of the U.S. Department of Agriculture, or the views of any theoretical governmental agency, but the views which Bill Sulzbacher, a bacteriologist, has acquired while looking at the meat industry and the meat consumer from the peculiar vantage point of a desk in a government research laboratory.

Just what is meat microbiology and what can the citizen reasonably expect of it in his quest for a safer, a cheaper, and a more nutritious food supply? One can paraphrase another famous definition and say that microbiology is what microbiologists do. Some of the things microbiologists do are important, worthwhile, and interesting; some are worthwhile but dull; and some are worthless but fascinating.

The founder of this study of small things, which we call microbiology, was a Dutch draper named Antonie van Leeuwenhoek and he was always fascinated by the large numbers of microbes in such quantities as a drop of canal water, a pinch of pepper, or a bit of tartar plucked from between his teeth. This fascination with numbers has persisted to our own day and one of the things microbiologists do is count the cells in a milliliter, a gram, or on a square centimeter of their favorite food. This is variously referred to as the standard plate count, the aerobic

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count, or the total count. None of these terms is entirely accurate, but so long as we understand what is meant, no great harm is done by the lack of accuracy. The important criteria of the plate count which should be defined are the temperature of incubation, the plating medium, and details of sampling. With this criteria understood, we know that the plate count tells us how many microorganisms are recoverable by a certain technique and under certain conditions from a particular sort of sample.

One of the serious problems with counts of microorganisms in meat products is the difficulty of obtaining a homogeneous sample. With a liquid, such as milk or water, it is comparatively easy to obtain a representative sample of the well-mixed material. It is almost impossible to do this with most meat products so that we must depend on large numbers of replicates and statistical treatment to gain an accurate idea of the numbers of organisms present at the time of sampling.

Having determined this number with due care and taking into consideration the technical limits of the procedure, what does it mean? Is it a worthwhile exercise to determine the number of bacteria recoverable from a ham, or a frankfurter, or some other product, which will grow on a stated kind of agar at a stated temperature? Or, to ask the question in another way, what use can we make of the information?

Of course, the great trouble with the aerobic plate count is its complete lack of specificity and this severely limits the uses to which it can be put. The only clues we have as to the sorts of bacteria counted come from the temperature of incubation and the composition of the medium. (To this, of course, the highly skillful bacteriologist can add subjective impressions based on long experience with particular products.) Thus, applied to fresh meat where numbers are not well correlated with quality, the aerobic plate count has little use. For a product whose preparation involves heat processing, the plate count may be quite useful as a measure of the sanitation observe in handling after processing.

This brings us to the most common, and perhaps one of the more controversial, uses of counts; that is, for establishing microbiological standards. In 1969, at this Conference, we had a very complete session on standards as they apply to meat products and, rather than repeat what was said there, I refer you to the proceedings of that meeting. Two or three matters do, however, bear emphasizing.

First, the concept of standards really need not cause so much heat as it does. Anyone who makes a judgment has some sort of standard in mind. When the diner says, "This is a good piece of beef", or "This is a lousy steak", he has in mind some standard to which he compares the beef or the steak in question. Considered in this light, there is really nothing formidable about a microbiological standard. It is simply a means of using some microbiological characteristic of the product for comparison with an expression of what is ideal, or perhaps, attainable, with respect to that characteristic.

With this in mind, let's return to our consideration of the aerobic plate count as it relates to meat standards and to what I personally feel are the needs of consumers. As indicated above, I see little scope for the use of official or legal standard counts in regulating chilled beef or lamb, or fresh pork. If, however, centralized packaging becomes more of a reality, I would expect that a firm buying packaged cuts could gain much by establishing upper limits for numbers of psychrophilic organisms on such cuts. As a consumer, I would not want to have local public health authorities seizing loins in beef-aging rooms because they yielded 20°C counts in the neighborhood of a million per square centimeter. To the layman, or even to the bacteriologist unschooled in meat science, these can be conflicting and puzzling matters. Here government can play an important educational role. So, also, can the meat industry. But in the current atmosphere of ardent consumerism, government is likely to be more creditable. When one considers diversity of meat products and variations among their types, it should be obvious that standards based only on total counts must be applied very cautiously and interpreted very carefully.

Of course, when the consumer thinks of bacteriological standards, he probably assumes that such such standards are intended to protect him from pathogenic or toxic microorganisms. Thus, some official standards contain words such as "shall not contain any coagulase positive staphylococci" or "shall not contain any salmonellae" (Levine, 1961). That such language can assure the absolute absence from the food of the specific disease agent mentioned in the statute is, to quote Ingram and Kitchell (1970), "a figment of the bacteriologist's imagination". Bacteriological analysis is destructive so that it is not possible to analyze the cake and eat it too. The most that the analyst can claim is that under the conditions of sampling and examination, none of the organisms under consideration could be recognized in a sample of a certain size. Thus, the sampling technique automatically involves a certain tolerance. When you hear someone say, "We have no tolerance for salmonellae", that is simply not true. The tolerance is automatically and, of necessity, determined by the sample size and the sensitivity of the method. Unfortunately, this rather obvious fact is often overlooked by bacteriologists and completely unappreciated by consumer advocates.

Early in the history of food bacteriology, workers in water sanitation developed the concept of the indicator organism. This is the theory that some readily recognized organism can be used as an indicator of the possible presence of a disease organism. As originally applied to water, the principle was that if the organism then called B. coli communis was found in water, it indicated that the water had been contaminated by human fecal matter and might, under the right conditions, contain dangerous organisms like S. typhi. It was not claimed that our friend E. coli, to give him his modern name, was himself dangerous, but only that he was an indicator of the possible presence of his more sinister relatives. As originally applied to water analysis, this was a rather reasonable concept. However, it was soon expanded to apply to milk, and then to food in general, and finally the indicator became, to many minds, not the specific bacterium, E. coli, but a whole family of organisms called the coliform group. Furthermore, it was mysteriously suggested that all the members of this group were in some way reprehensable in themselves. Indeed, this concept of the indicator organism has been so seriously abused that it now is of very doubtful validity, from either a scientific or a legal standpoint. Time does not permit us to delve further into this interesting matter, but I earnestly urge you to read the paper, "Facts and Fancies of Bacterial Indices in Standards for Water and Food", by Max Levine (1961), remembering that he is the man who invented the now famous EMB agar, the basis for countless E. coli determinations. Certainly, for raw meat products we have no currently acceptable indicator organisms. For heat-treated products, the original concept has validity if properly refined as to technique and if intelligently interpreted.

One of the problems in using indicator organisms is the tendency of bacteriologists to use each other's techniques as a substitute for either brains or work. For example, a medium known as violet red bile agar is much used in dairy laboratories for detecting coliforms. This has been liberally borrowed, and I have seen specifications for meat products which required a minimum coliform count on violet red bile agar, completely ignoring the fact that coliform counts so obtained, and from meats or meat products, have practically no significance.

Of course, the great need in correcting the faults I have mentioned is for more knowledge. Here the government scientist can play an important role. A few of our larger companies maintain excellent research and quality control laboratories. More of the meat industry operates on faith; faith that the federal or state inspector will keep them out of serious trouble with both the regulations and spoilage bacteria. This is a situation where everyone concerned needs more knowledge. The inspector, management, workers and consumers all need to know more about meat as a biological material. The needed knowledge will be developed in many quarters, but government at all levels can do much to encourage the necessary research, to disseminate the results, and to put them into practical use. Particularly, the operators of small meat processing plants must look to government for assistance and guidance.

Some future needs on which we ought to begin work now deserve special mention. The relationship between the strongly aerobic pseudomonads and microaerophilic lactics ought to be better understood as they affect meat spoilage. New devices and techniques are needed to give us fresh meats with very low initial mcirobial loads. Rapid means are needed to isolate and identify pathogenic or toxigenic microorganisms so that we can all do a better job of keeping them out of our meat products. We ought to know more about food-borne viruses and their relationship to food safety.

In the matter of new and more rapid means of identifying microorganisms, the government scientist can play an especially important role. Since the processor must conform to government regulations, his techniques for detecting pathogenic or toxic organisms must be at least equal in sensitivity to those of the regulatory laboratory. However, the regulatory laboratory need not be in any hurry, so that highly sensitive but time-consuming methods are often used. This works an obvious hardship on producers. New methods based on automatic devices which can apply biological criteria to a large number of samples in a limited time are now possible. Prototype machines which can identify microorganisms by fluorescent antibody and other techniques already exist. The perfection of such machines and their general adoption by regulatory and private control laboratories can greatly speed up the work to be done, and save processors from unreasonable waiting periods to clear samples. Likewise, such automated procedures, since they demand a high degree of uniformity of reagents and procedures, will help in standardizing techniques; and, since techniques imply tolerances, as we have pointed out above, more uniform standardization will result in more universal adherence to the same tolerances. This concept is well developed in other industries. Witness the unified thread systems whereby British, Canadian, and United States manufacturers adhere to the same dimensional tolerances for threaded machine parts and for nuts and bolts. In meat microbiology, if everyone used a machine of the same type for identifying salmonellae, for example, everyone would then be working within the same framework of sample size, enrichment cultures, and identifying reagents. I believe this situation is nearer to realization than you may think, and I believe government scientists will be leaders in its development.

Another area where uniformity is important is in international trade. We in meat microbiology are rather new to the problem but almost 30 years ago some American agricultural products were denied entry to Great Britain because of their content of pathogens. If meat products are to move freely in international commerce it is obvious that the inspection services of the various countries will have to work to universal specifications for laboratory methodology. Work is already going forward in this direction. Dr. F. S. Thatcher is Chairman of an International Committee of the International Association of Microbiological Societies which is concerned with standardizing laboratory methods throughout the world. Their approach is to distribute samples to selected laboratories in many countries to test collaboratively the methods in use. It is only by this means that bacteriologists in various countries can be brought to give up favorite methods for ones of demonstrated superiority.

At the beginning of this rambling account I asked what the citizen might expect of meat microbiology. The answer I would give is that he must expect rational attacks on problems based on carefully analyzed facts. The citizen can expect us to discard not only our old myths inherited from the pre-scientific age but also those we have lately created, such as a zero tolerance for certain bacteria. Most of all, the citizen must look to the meat microbiologist to give help and guidance to all segments of the meat distribution chain, so that we can continue to enjoy a plentiful supply of wholesome meat at favorable prices.

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