Viral Hazards in Meat

Dean O. Cliver*

In recent years, there has been increasing concern over the transmission of viruses to humans through foods. Meats and meat products have been especially suspect because it is well known that food-source animals are themselves subject to virus infections that might lead to contamination of the edible flesh. As it happens, the epidemiologic record does not support this concern.

For the purpose of the present discussion it seems appropriate to begin with a brief functional description of what viruses are. Viruses are transmitted through foods in the form of extremely small particles, ranging in size approximately from 25 nanometers to less than 100 nanometers in diameter. They are simple in construction, consisting usually of a random coil of nucleic acid with a protein coat outermost. A few have an additional, lipid-containing envelope, but these will not figure further in this discussion. The particles are roughly spherical in shape and are totally inert, in the sense that they cannot carry out any of what are commonly regarded as life processes.

This inertness is, of course, not quite what it seems: viruses are of concern to health because of their ability to produce infections, some of which result in disease. They do so on a very selective basis. Viruses that infect humans tend not to be capable of infecting other species, with the exception of our closest evolutionary relatives. Furthermore, viruses that infect other animal species tend not to be infectious for humans. The exceptions, viruses that are occasionally transmitted from animals to man (zoonoses), are not known to be transmitted through meats and meat products. In addition to their species specificity, viruses show a distinct individual preference for infecting certain tissues or organs of the host's body. This tissue specificity determines which cells of the host's body become infected and thus what symptoms are likely to result from the infection.

Whether or not they cause disease, virus infections tend to be self-limiting. The body's immune processes ordinarily suppress a virus infection after some period of time, so the persistence of viruses as obligate parasites is based on the ability of these agents to pass from host to host. Viruses that infect humans are principally transmitted directly from person to person, either by actual touching or by aerosols over short distances. However, they are also capable of being transmitted indirectly through food and water, as well as a few other means.

Virus contamination of foods has been categorized as primary or secondary, depending upon whether the virus was already present in the foodstuff at the time of harvest or slaughter. In the case of meats and meat products, the viruses that are already present at the time of slaughter are of little concern to human health. Instead, the outbreak record indicates that what problem there is lies in secondary contamination, most frequently through mishandling of food by a person with an intestinal virus infection. Human intestinal viruses in sewage have also contaminated meat products; but neither insects nor rodents are known to have served as vectors in secondary contamination of meats, despite the obvious possibility that they might do so.

Contamination of meat does not guarantee that a consumer infection will result (nor, for that matter, do most virus infections result in overt disease). Virus that has been introduced into meat cannot possibly multiply, but may be inactivated (deprived of its infectivity) before the meat is eaten. This can come about in a number of ways, the one of most practical significance being thermal processing or cooking. The times and temperatures required for virus inactivation in meat cannot be specified precisely. Viruses in a rare steak probably are no threat to human health because viruses within the muscle are likely to be of animal origin and therefore not infectious for the consumer. Viruses in ground beef, however, may be of human origin: the heat stability of viral contaminant varies with the fat content of the ground beef, but complete inactivation can apparently be assured by cooking the meat until all pink color disappears from the center. Virus on the surface of meat can probably be inactivated by ultraviolet light, and ionizing radiation can inactivate virus in subsurface locations. Although the coat proteins of some viruses are apparently biodegradable, microbial decomposition of meat through prolonged storage evidently has little effect upon the virus. There is one important exception to some of the above generalizations that should be mentioned: the virus of foot and mouth disease, which is no direct threat to human health but has great economic significance, is chemically degraded in voluntary muscle by the acid of rigor mortis but is protected from this, and withstands a great deal of heat, in lymph nodes, bone marrow, and large blood clots.

Many kinds of viruses in meat can be detected on the basis of their ability to produce infections in cell cultures. The absolutely necessary steps in the detection process are to make a fluid suspension of the sample and inoculate it into a culture of susceptible cells; however, in practice, several additional steps are usually required. Cultures of primate cells are ordi-

*D. O. Cliver, Food Research Institute, University of Wisconsin, 1925 Willow Drive, Madison, WI 53706

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narily used to detect viruses that are of significance to human health, but no type of cell culture is known to be susceptible to the virus of hepatitis A or to some of the viral gastoenteritis agents. The methods that are available are used, despite their cost and complexity, because there are no valid indicators (microbial or other), the presence of which would signal that virus contamination had occurred.

A few surveys have been reported in which plant or market samples of meats and meat products have been tested for viral contaminants. Ground beef has attracted a great deal of attention since the publication of a survey by the U.S. Food and Drug Administration in which human viruses were detected in market samples. More recent surveys have tended not to confirm this finding; but, as will be described below, an outbreak of hepatitis in Amsterdam has shown that viral contamination of ground beef can be a threat to human health. A limited survey done by my group showed that in some areas, intestinal virus infections are common in slaughter animals. Viruses were also found in some by-products, but the viruses apparently were not infectious for humans, and none were found in market samples.

Recorded outbreaks of human viral disease associated with meats have included only hepatitis A, a lingering, debilitating disease that is very specific for humans and is transmitted by a fecal-oral cycle. It seems clear that other human intestinal viruses might well be transmitted through meats in the same way on occasion, as is beginning to be observed with other foods. On the other hand, it does seem noteworthy that there are no zoonoses in the outbreak record and that, where this could be determined, all of the events of contamination that led to outbreaks took place in food service or retail establishments. I shall enumerate three outbreaks that seem to represent the scope of the problem. In Amsterdam, The Netherlands, an infected butcher contaminated steak tartare (seasoned raw ground beef) in such a way that approximately 21 consumers became ill with heptatitis A. In Morris County, New Jersey, a sewer backup in a delicatessen contaminated cold cuts that infected approximately 40 consumers; two of the store workers also became infected and later contaminated enough food to cause 27 more consumer illnesses. In Bushey Hall, England, the manager of a cafeteria at a school for U.S. Air Force dependents worked while ill and apparently contaminated roast pork (during boning and slicing) sufficiently to cause illness in approximately 22 students and faculty. In each of these instances, the virus that contaminated the food originated in the human intestines: contamination was either direct, or indirect by way of wastewater.

In summary, the record of the food-associated viral disease reveals no zoonoses that are transmitted to consumers via meat. However, viruses that originate in the human intestines are as likely to contaminate meats as other foods and, if not inactivated before the meat is eaten, may cause infections in consumers. Recorded incidents have resulted from mishandling meat in food service or retailing, rather than in slaughtering or processing. Viral contamination of meats can be avoided by the same precautions in sanitary food handling that are applicable to any other food. From the standpoint of human health, the viral hazard associated with meats is significant, but by no means as severe as those of botulism or salmonellosis.

Discussion

J. D. Fox, University of Kentucky: What is the availability of chemical sanitizers that can be effective against viruses?

D. O. Cliver: In fact, the strong oxidizing agents are quite effective against viruses exposed on surfaces, but if they get into a meat in some way, why they are not going to be accessible to that. We are in my own laboratory, working on means of disinfecting virus contaminated fingers as well because that seems the way viruses get onto food. This is a matter of considerable concern to us and I would be very tempted to go off into yet another research presentation on that, but I think not.