CANADIAN MEAT SCIENCE ASSOCIATION

Under the Microscope: Incidence of Pathogenic Viruses in the Food Chain

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Introduction

The Centers for Disease Control sets the estimated number of foodborne diseases in the US at 76 million annually, with 325,000 hospitalizations and almost 5,000 deaths (Table 1). Foodborne illness can be caused by bacteria, parasites, viruses, prions, toxins and metals. It can cause gastroenteritis, and neurological, liver and kidney syndromes ranging from the benign to the extremely serious in some cases (Mead et al., 2000). In a little over 80% of foodborne diseases, or 62 million, the agent is unknown; out of the 14 million cases for which pathogenic agents have been identified, 67.2% are associated with viruses (9,282,170 cases), 30.2% with bacteria (4,175,565 cases) and 2.6% with parasites (357,190 cases) (Table 2) (Mead et al., 2000).

At 15-250 nm, viral infectious agents are smaller than bacterial ones, which measure 1-5 µm, and they always require a compatible intact host cell to reproduce. Enteric viruses (which infect the gastrointestinal tract) include Norwalk-like viruses, the hepatitis A virus, certain rotavirus serotypes, certain adenovirus serotypes, the hepatitis E virus and astroviruses.

Enteric viruses

Enteric viruses are becoming increasingly common agents of infection causing acute gastroenteritis in humans (Cliver, 1994; Kapikian, 1996; Mead et al., 2000). The life cycle of a virus starts when it attaches itself to a compatible host cell. The virus penetrates the cell membrane and injects its genetic material (DNA or RNA) into the cell. All the host cell's metabolic functions are then taken over by the virus for the multiplication of its genetic material, the production of viral proteins and, ultimately, the assembly and production of thousands of new infectious viral particles. Frequently, the infected cell is destroyed at the end of the process to release the new viruses that have been produced.

Even though enteric viruses cannot multiply outside of their host cell, they are often highly resistant and survive in the environment for long periods of time. Their infectious potential is determined by the original quantity, and low doses would be enough to cause infection in humans (10 viral particles for rotaviruses and 10-100 viral particles for hepatitis A).

The most common and best known routes of transmission of enteric viruses to humans are the fecal-oral route, water, ice, crustaceans and other seafood, and the handling of food by infected individuals. However, with the development of techniques to detect enteric viruses, recent studies are pointing to ready-to-eat food, fruits, vegetables, dairy products and animal products as possible transmission routes to humans (Cliver, 1994; Kapikian, 1996; Mead et al., 2000).

Hepatitis A virus

The hepatitis A virus was discovered in 1908 and has spread world-wide, occurring sporadically or as an epidemic in certain countries. The hepatitis A virus belongs to the *Picornaviridae* family and has so far been found in the form of four different genotypes (or genetic types). It is non-enveloped, icosahedral, measures 27 nm in diameter and has single-stranded RNA with positive polarity (able to code directly for protein) measuring about 7.5 kilobases in length. The hepatitis A virus can survive from 3 to 10 months in water and is not affected by freezing. It can be inactivated by radiation or heat treatments at 56°C for at least 30 minutes, or at least 85°C for at least 1 minute. However, the presence of fat in the virus environment increases its heat stability.

Foodborne hepatitis A infection is accompanied by fever, anorexia, nausea, abdominal cramps and fatigue that often result in jaundice and, in more serious cases, permanent damage to some liver functions.

Norwalk-like viruses

Norwalk-like viruses were identified in 1972 by electron microscopy of the stools of a patient with acute gastroenteritis following an epidemic in Norwalk, Ohio. Norwalk-like viruses belong to the *Caliciviridae* family and so far have been found in the form of 13 separate genotypes often identified by the epidemic location (Hawaii, Snow Mountain, Montgomery, Taunton, Amulree, Sapporo, Otofuke, etc.). They are non-enveloped, icosahedral, measure 27-40 nm in diameter and have single-stranded RNA with positive polarity measuring about 7.6 kilobases in length. Norwalk-like viruses remain infectious even after years of freezing, after heat treatment at 60°C for 30 minutes, or 30 minutes of treatment at high chlorine concentrations (6.25 mg/L). They are also resistant to pH levels of 5-10, to diethyl ether and to acids.

Norwalk-like viruses are held responsible for at least 65% of food poisoning cases in the US and, because no effective means of detection yet exist, could also account for many of the unexplained cases. Norwalk-like virus infection is

accompanied by fever, headaches, nausea, vomiting, abdominal cramps, diarrhea and, in some cases, shivers and muscle pain.

Foodborne Norwalk-like virus infections are often associated with water, oysters and mussels, but recent studies have identified them in the intestinal contents of hogs and calves in Europe and Japan. Farm animals are suspected of acting as a reservoir for these enteric viruses (Sugieda et al., 1988; van der Poel et al., 2000).

Hepatitis E virus

The hepatitis E virus was identified by electron microscopy in 1983. Very little information is available about this emerging virus, which is currently associated with the *Caliciviridae* family. It is non-enveloped, icosahedral, measures 34 nm in diameter and has single-stranded RNA with positive polarity. Hepatitis E and hepatitis A virus infections are difficult to distinguish from each other, as the symptoms are often the same.

Rotaviruses

Rotaviruses were identified in 1978 by electron microscopy of the stools of a patient with acute gastroenteritis. Rotaviruses belong to the *Reoviridae* family. They are non-enveloped, icosahedral viruses with two layers, with a diameter of 70 nm and 11 double-stranded RNA segments representing 18.2 to 30.5 kb. Rotaviruses are viable for months at 4°C and 20°C or at an acid pH (3.0-3.5). On non-porous material at a low temperature with humidity, they remain infectious even after several days. However, they can be inactivated by temperatures above 50°C.

Rotavirus infections are very common in developing countries and are responsible for the deaths of approximately 2,000 children per day. The infections are accompanied by fever, headaches, nausea, vomiting, abdominal cramps and, in some cases, temporary lactose intolerance. It takes only 10 viral particles to cause infection in humans, while there are up to 10^8-10^{11} particles/ml of stool in infected patients. Rotavirus infections are generally benign in industrialized countries.

Conclusion

In the US, 82% of food-related illnesses come from unknown pathogenic agents. At present, there are no effective means of detecting enteric viruses in foods, and these viruses (primarily Norwalk-like) are increasingly suspected of being responsible for a high percentage of unexplained food-related illness.

The Food Research and Development Centre, Agriculture and Agri-Food Canada, and the Health of Animals and Food Laboratory, Canadian Food Inspection Agency, have decided to combine their efforts and undertake a joint research program to study the incidence and prevalence of enteric viruses in

foods. The research team has spent a little over a year developing methods to detect enteric viruses in foods. It also plans to study the presence and prevalence of enteric viruses in foods, and assess their stability and the effectiveness of control measures. With colleagues from Health Canada and academia, a Food and Environmental Virology Network (FEVN) is also being established to provided scientific discussion and optimise linkages among institutions and laboratories involved in food virology nationally.

References

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Table 1. Food-related illness and death in the US.

Identified agent	# Cases (%)	Hospitalizations (%)	Deaths (%)
Bacteria	4,175,565 (30.2)	36,466 (59.9)	1,297 (71.7)
Parasites	357,190 (2.6)	3,219 (5.3)	382 (21.2)
Viruses	9,282,170 (67.2)	21,167 (34.8)	129 (7.1)
Total	13,814,924 (100)	60,854 (100)	1,809 (100)

Source: Mead et al., 2000

Table 2. Pathogenic organisms identified as being responsible for food-related illness and death in the US, as a percentage of the total.

Agent	# Cases (%)	Hospitalizations (%)	Deaths (%)
Identified pathogens	14,000,000 (18.5)	60,000 (18.5)	1,800 (36)
Unknown pathogens	62,000,000 (81.5)	265,000 (81.5)	3,200 (64)
Total	76,000,000 (100)	325,000 (100)	5,000 (100)

Source: Mead et al., 2000

Fig. 1.

THE GROWING CHALLENGE FROM ALKALITROPHIC PSYCHROTROPHS IN MEAT PROCESSING.

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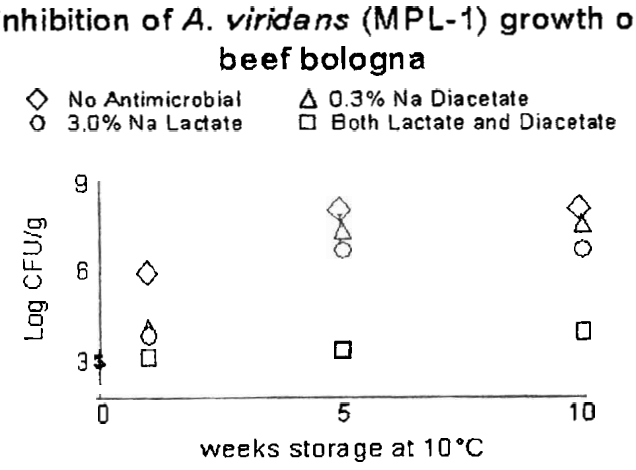

Growth of *A.viridans* in inoculated vacuum packed bologna sausage formulated with either or both lactate and diacetate. Discolouration of untreated bologna was evident at 7 d storage and at 35d in the diacetate treatment upon package opening. All lactate treatments prevented colour change.