

## The Safety of Food: A Personal Overview



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Enteric disease has been with the human population for as long as historical records have existed but their causes have only been determined through extensive research which still continues today. The Romans, for example, wrote about the importance of setting up camps where latrines were downstream of water intake, and piped in fresh water from distant locations to urban centers through aqueducts, but food was more problematic because there was no one source that could be controlled. In medieval times, at least in Europe, shallow wells were no longer adequate for growing populations and could become contaminated through polluted ground water, especially human sewage, and that made contamination of food much more likely. Farmers' stalls, urban retail food stores, street food vendors and fancier restaurants serving both local and imported foods meant that more often than not, customers had to make judgments on what foods were safe and what not. As food began to be transported longer distances with more people involved in the production chain and those exposed, larger and larger outbreaks would occasionally occur. **Milk was the first food that was almost universally consumed if it could be obtained, and the market created opportunities for milk to be delivered to communities far from its farm sources.** Then, large-scale milk-borne outbreaks began to plague Victorian societies the UK and the USA and continued into the 1920s. One of the reasons was adulteration of the milk by diluting with unsanitary water by middlemen. But eventually with pasteurization being more widely adopted and adulteration much less common, these milk-borne outbreaks diminished. However, after

World War II with the creation of many food service outlets and expansion of processed food for the public, environmental health personnel had to focus on a much more diverse set of food sources. However, surveillance of food borne disease and other infectious diseases was not very extensive and outbreaks seem to be rare, and many public health authorities considered that infectious diseases were no longer a problem. For example, in 1968, the U.S. Surgeon General noted that "it might be possible with interventions such as antimicrobials and vaccines to close the book on infectious diseases and shift public health resources to chronic diseases." How wrong this thinking was. Although the management of chronic diseases and malnutrition required new research and policies, infectious diseases were far from disappearing, including those associated with food. **Up till the 1950s, the so-called "big three" were *Salmomella*, *Staphylococcus aureus* and *Clostridium perfringens* with occasional concern over the presence of *C. botulinum*.**

In the research group I worked with in the late 1960s and early 1970s, the research was focused on methods to detect *C. botulinum*, *S. aureus* and *Salmonella*. But a decade later, other pathogens in the food supply were detected through better surveillance methods based on investigation of outbreaks. These included *Campylobacter*, *Escherichia coli*, *Listeria monocytogenes*, *Vibrio parahaemolyticus* and *Yersinia enterocolitica*.

For instance, *Listeria monocytogenes* was first recognized as a foodborne, as opposed to a purely animal, pathogen in 1981 after an outbreak of cabbage cole slaw occurred in Eastern Canada where cabbages had been fertilized with manure from a flock of sheep that were suffering from listeria-related abortions and deaths. It was determined that during the winter storage of these cabbages the *L. monocytogenes* grew slowing on the leaves even at refrigeration temperatures to cause 41 case infections (34 perinatal and seven adult cases) as a result of eating the commercially sold cut cabbage (cole slaw). Individuals who have an underlying condition that leads to suppression of their T cell-mediated immunity account for the majority of cases of listeriosis, which manifest in a number of syndromes, usually bacteremia and/or meningoencephalitis.

Predisposing conditions associated with listeriosis include neoplastic disease, immunosuppression, pregnancy, the very old and the very young, diabetes mellitus, alcoholism, cardiovascular and renal collagen diseases, and dialysis-dependent renal failure (Conly and Johnston, 2008). Since then, many other foods have been impacted in outbreaks of listeriosis often with fatal consequences; these include soft cheeses, pasteurized milk, butter, chocolate milk, deli meats, hot dogs, smoked fish and mussels, corn (maize), and cantaloupes. These early outbreaks forced governments to develop and implement control measures on this pathogen and today in many countries including the U.S. and Canada it is considered to be unacceptable to be present in ready-to-eat (RTE) food at any level (zero tolerance). This puts a burden on farmers and producers to institute plans to minimize the risk of human listeriosis arising from the consumption of the RTE products they market. Despite prevention and control policies in place, two large widely publicized outbreaks show that this pathogen still has much to teach us, one from a large modern processing plant and the other from a farm that had been given a positive report by a third party auditor. In 2008, 57 cases and 23 deaths in eastern Canada were linked to RTE deli meat products from a major Canadian manufacturer. The very large slicing machines were hard to clean and sanitize and thus were not disassembled frequently enough to prevent colonization of the pathogen in the meat particles remaining in the slicing blades and associated machinery. A similar problem occurred in 2011 resulting in 147 people suffering from listeriosis in 28 U.S. states with a total of 33 deaths after they ate cantaloupes produced from a farm in Colorado. The cantaloupe contamination most likely occurred during the washing and drying process, which was not designed for easy cleaning and sanitizing. Unfortunately, *L. monocytogenes* occurs frequently in the environment and can easily colonize damp niches such as drains and cracks in walls in production facilities. In both these outbreaks the pathogen resident in the equipment could regularly contaminate product as it went through the processing steps, and it did not receive a terminal decontamination treatment before shipment. **Growth could take place at any point between transportation from the producer to the retailer and the home of the consumer, especially as it can grow slowly in refrigerators.** Furthermore, neither of these products was cooked or otherwise treated to destroy any of the *Listeria* that had multiplied. To indicate that this pathogen is an ongoing concern, in August 2014, there



are so far there are 28 ill and 13 dead after eating product sold through a Danish sausage company. Interestingly, researchers in Denmark are exploring the mechanisms of how *Listeria monocytogenes* can be such a dangerous pathogen, and have discovered that they can release certain RNA molecules to regulate both cell invasiveness and protection from hostile host immune systems (<http://www.sciencedaily.com/releases/2014/08/140827100224.htm>). This is just one example of an emerging pathogen that continues to plague our society despite our increased knowledge and best efforts at control. Other pathogens that give the food industry and public health authorities equal concern are the many strains of *E. coli* including O157. One large outbreak that generated much publicity occurred from leafy green spinach produced in California in 2006, and was found to be related to animal-contaminated crops. More recently in 2011 an even larger outbreak arose from O104:H4 in fenugreek sprouted in Germany with thousands ill and 53 deaths; this was caused by an enteroaggregative *E. coli* (EAEC) strain that had acquired the genes to produce Shiga toxins, present in fenugreek bean sprouts. The economic damage was high, not only for medical costs but also for public's concern over the safety of any vegetable retailed in Europe. In fact, because of a mistake early in the investigation, Spanish cucumbers were suspected to be the contaminated vehicle and much of that year's crop was wasted. The highly versatile *Salmonella* remains as the pathogen with outbreaks arising



slaughter worldwide program. However, this vCJD finding opened the door for research into a whole group of transmissible spongiform encephalopathies found in nature. In the last two decades, viruses and parasites have been linked to many outbreaks. Starting in 1997, *Cyclospora cayentanensis* caused outbreaks in the U.S. and Canada from raspberries in a newly created industry to capitalize a demand for out-of-season fruits in these countries. Irrigation water was probably responsible but not proven; no matter, the demand for such Guatemalan fruit was lost. Since then, foodborne *Cyclospora* outbreaks have been reported in the U. S. have been linked to several types of imported fresh produce, including basil, snow peas, and mesclun. In July of this year, there were over 200 cases of cyclosporiasis served in restaurants in where cilantro imported from Mexico was discovered to be the source. This follows on an even larger outbreak in June 2013 also from imported cilantro from Mexico with 631 people sickened in 25 states. In recent years with better detection methodology, norovirus has now been shown to be the number one pathogen causing foodborne illness in the U.S. and other countries, through food contamination and also person-to-person transmission in restaurants, schools, and notoriously in cruise ships.

**One common factor in most of these is that the demand for freshness, better nutrition, less fats, and fewer calories but has resulted in unexpected consequences with increased disease risks to consumers. Also, there are some members of the public who prefer natural to processed food and are willing to take the risk of contacting infections; these include raw milk and raw milk cheeses, unpasteurized apple cider/juice, raw shellfish, unpasteurized almonds, and rare or raw meat.** How does society respond to these people? Does choice trump public health or vice-versa? I think today, policy-makers are listening more to those who want choice, but this complicates prevention and control strategies long promoted by public health agencies. Regulations, guidelines and education can have some impact for change, but in the long run these individuals will find ways to seek out and consume their desired products. Maybe informed adults can be allowed to accept these risks but what about the immunocompromised or very young and very old? As long ago as 1920, C.E.A. Winslow defined public health as “the science and art of preventing disease, prolonging life and promoting health through the organized efforts and informed choices of society, organizations, public and

from the largest variety of food vehicles from chicken to chocolate to peanut butter, and in Lebanon there have been a number of recalls from tahini. As sesame seeds are the main ingredient, it remains an open question whether the *Salmonella* originates from the seeds harvested in many African countries or from the processing plants themselves, an area to explore through surveys and research.

Other concerns were and are *Cronobacter sakazakii* in infant formula, vibrios in shellfish, and drug-resistant *Salmonella* in meat. The meat crisis off the 1990s with “mad cow disease” or bovine spongiform encephalopathy (BSE) eventually discovered a new form of agent, prions, capable of killing those exposed after eating heat-processed cow meat causing variant Creutzfeldt-Jakob disease (vCJD). BSE today is controlled by a vigorous

private, communities and individuals”, a statement well before its time by envisaging multidisciplinary thinking with medical, scientific, and societal components to actually make change possible. This opens up the door for research by academics into public relations, education, and sociology, in collaboration with government and industry, into approaches to be applied to food safety issues.

Another food safety issue is the extent where food ingredients come from. Today, every food manufacturer has to consider purchasing ingredients from many sources, some of which may be from uncontrolled environments in distant lands. This uncertainty with risk of recall, loss of business, fewer trading partners, or worse with the possibility of an outbreak, has led to considering traceability oversight throughout the food chain monitored by properly trained and experienced third party auditors. Just as the Meat Inspection Act of 1906 in the U.S. was to create better sanitation conditions in meat packing plants, and also to give importers a better sense of security that what there were importing was good quality and safe meat, so the traceability approaches today such as those of the Global Food Safety Initiative (GFSI) is to foster collaboration with industries for the continuous improvement of food safety management systems. The GFSI was launched in 2000 following a number of food safety crises when consumer confidence was at an all-time low. Current activities include the definition of food safety requirements along the entire food supply chain to cover components such as feed, distribution and packaging. The development of a capacity building program for small and/or less developed businesses is facilitating their access to local markets and a focus on food safety auditors is bringing industry experts to common consensus on the skills, knowledge and attributes that a competent auditor should possess.

The topic of food safety is very broad, and I have not touched on many other issues such the development and acceptance of genetically modified organisms (GMOs), bovine somatotropin (BST) or recombinant bovine growth hormone (rBGH) milk, and food irradiation which are promoted more in North America than in Europe. However, even in the U.S. and Canada there are pressures to use these less and less. These technologies have definite benefits for production, and in the case of irradiation, for safety, but consumer concerns force manufacturers to be wary of them. For example, even though irradiation of chicken is permitted in the U.S. which not only destroys

commonly-present *Campylobacter* and *Salmonella* on the carcasses and prolongs shelf-life, no manufacturer is selling irradiated chicken because of public fear of that technology. Nevertheless, in the future, with increasing concern over climate change and drought, some societies may be forced to reconsider the use of GM drought-resistant varieties of crops to be able to prevent starvation. Concern over the safety of animal clones is not in question as they are identical to the parent, but whether agriculture will ever pursue this approach to produce more effective protein sources is uncertain. However, many technologies developed to replace heat inactivation of microorganisms in certain foods, and these include high pressure processing, membrane filtration, ohmic heat processing, pulsed electric field pasteurization, and pulsed light are in use. Nanotechnology has yet to make great inroads in the food industry, unlike in other areas of modernization of our civilization and is being reviewed for any possible food safety concerns. Much more detail on the many components of food safety can be found in the Encyclopedia of Food Safety (Motarjemi et al., 2014).

All this information means that food manufacturers, retailers, and food service operators have to take the initiative to improve their awareness of risks and establish more effective safety plans. Today, because of the new Food Safety Modernization Act in the U.S., food producers in countries like Lebanon must satisfy FDA inspectors and have the facilities and HACCP (Hazard Analysis and Critical Control Points) and traceability plans for their products and their ingredients in place to be allowed to export to the U.S. The continued concern over foodborne disease and food safety in general means there are many opportunities in academia, government and industry to collaborate for research. Universities and colleges in Lebanon and the Middle East in general have to capitalize on encouraging appropriate food safety courses and supporting research for a new generation of food safety specialists and educators.

## References

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