Pathogenic microbes in water and food: changes and challenges

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Despite the progress seen in recent times in medical care and food technology, food- and waterborne diseases are still (and increasingly) of major concern for human health, both in developing and in developed countries. Except for the obvious epidemic case, food- and waterborne diseases go frequently unrecognised and the impact on human health and economy is underestimated. It is estimated that incidents of food-borne illness worldwide are in excess of 1 billion cases per annum, not taking into account the social costs and impacts.

Considering food- and waterborne diseases, our society has gone through significant changes, particularly over the last two decades. Worldwide, there is a dramatic population growth with expanding poverty and low standards concerning the status of food and water hygiene. Furthermore, it appears that more persons than ever are highly susceptible towards infections because of malnutrition, low medical service, ageing, or immuno-compromisation. Also our mobility on this planet has increased, not only due to tourist and business activities, but sometimes also because of political or economic reasons. Last but not least, and this applies particularly to industrialised countries, our living and eating habits have altered; this is reflected not only in the kinds of preferred foods, but also in their production and preparation technology, as well as their distribution and storage. As a result of such globalisation, we are faced with a shift in the spectrum of the most important pathogens and their properties.

Over the last two decades a continuously growing number of microbes, so-called ‘emerging pathogens’, have been reported to be of concern. In this context, one should recall that the term ‘emerging’ is used to indicate that these pathogens appear to have increased in their abundance in certain regions, for organisms that were either overlooked or were difficult to identify, and also for species for which the role of food and water as transmission vehicles has been recognised only recently. The spectrum of ‘emerging’ pathogens relevant for food and foodstuff differs from that problematic for water. In food, it is mainly the members of the bacterial group which have recently attracted most attention. Salmonella enteritidis, multidrug-resistant Salmonella typhimurium DT 104, Escherichia coli serotype O157:H7 and Campylobacter jejuni or coli) are generally associated with outbreaks of food of animal origin. Furthermore, Listeria monocytogenes, a psychrotrophic organism, can also be regarded as an ‘emerging’ pathogen since growth in processed meat, milk and fish products during storage (together with a relatively low infection dose) was the reason for recent outbreaks in developed countries such as Australia, France, the USA and Switzerland. A new type of infectious agent was identified with the detection of prions, for example, the BSE agent (inducing bovine spongiform encephalopathy) from contaminated bovine food that has been linked to a new transmissible spongiform encephalopathy in humans. For water, including drinking water and water for recreational activities, the list of the most important emerging pathogens is broader and includes viruses (Calici and other viruses), bacteria (pathogenic E. coli, Yersinia, Legionella, and Aeromonas strains) and protozoa (Cryptosporidium, Giardia, Entamoeba histolytica).

It is not only the pathogenicity of these organisms, i.e., the toxins they are producing and their virulence factors, which is of concern. Two additional aspects, demonstrating the high degree of flexibility and survival strategies of pathogens, have become equally important. Firstly, it is their ability to easily acquire resistance to one or more antimicrobial drugs. Secondly, it is their capability to transfer the genetic material related to pathogenicity (e.g., located on the so-called pathogenicity islands) and resistance-carrying DNA segments (transposons, insertion elements) horizontally to other organisms. Recently, it has been demonstrated that horizontal transfer of virulence factors and antibiotic resistance determinants takes place in the intestine of warm-blooded organisms and in the environment. For example, enterococci constitute a con-
siderable part of the commensal, harmless intestinal flora of animals and humans. Since multi-resistant enterococci are omnipresent in foodstuffs and since they are highly specialised in acquiring and distributing plasmids among Gram-positive bacteria, they represent a new dimension of food-mediated transfer of genetic material. Over the last decade the number of vancomycin- or multi-resistant enterococci that have been isolated from patients expressing at the same time a variety of virulence factors has increased dramatically. However, it is still unknown whether or not virulence associated genes display a mobility similar to that observed with antibiotic resistance genes. Due to horizontal gene transfer events the evolution of new pathogens and the re-emergence of repressed pathogens (such as multi-resistant *Mycobacterium tuberculosis* strains) have reached a frightening dimension.

The recent advances in the fields of biochemistry, immunology, genetics and nano-technology have also introduced considerable changes regarding speed, sensitivity and specificity of new technologies. Molecular techniques, originally developed in the field of medical diagnostics, which allow the detection and identification of pathogens, are now becoming available. Furthermore, increasing genomic and proteomic information on pathogens reveals so far unknown properties of these organisms. Several methods using specific DNA and RNA sequences or certain cellular structures (e.g., surface components) as targets are now already used in the analysis of food and water quality. Mostly, this change in techniques goes along with a faster and/or more selective identification of pathogens. Even ‘non-culturale’ species can be detected with such methods. However, although these methods represent very promising tools for the future, many of them still need improvement with respect to robustness and reliability before they will be applicable for routine analysis.

It is our intention to present in this Special Issue selected examples of the broad spectrum of viral, bacterial and protozoan pathogens linked to food- and waterborne diseases, rather than to provide a complete list. Besides the ‘emerging’ pathogens mentioned above most of the ‘classical’ pathogens are still a matter of concern, in particular — but not only — in developing countries. *Salmonella, Campylobacter, Clostridium*, and *Staphylococcus* spp. are well known to cause food-borne diseases, and the ‘classical’ water-related pathogens include *Vibrio, Salmonella, Shigella* species and the hepatitis A virus. Clearly, the importance of different pathogens depends on many factors, such as climate, cultural habits, agricultural practices, economical situation, health care, the demographic structure and many more. To illustrate this for the field of drinking water quality: primary attention is focussed on *Cryptosporidium* in the USA, Australia and the UK, whereas *Campylobacter* appears to be the most serious problem in Sweden.

We hope that the topics selected in this issue will stimulate the general interest in the microbiology of food- and waterborne diseases and may help to increase the efforts towards understanding the mechanisms of pathogenicity and the ecology of the different pathogens and that this may lead to an improved safety of water and food.