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# Point of view

## Adapting to changes in food systems: scientific challenges ahead

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*Given the rapid and constant changes that are occurring in all the phases of food systems, i.e. production, processing, distribution, and consumption, public- and private-sector players in the area of food safety need to have suitable analytical tools to ensure improved prevention and control of risks to consumers.*

Food systems, including all players, institutions, and technical tools that form a link between primary production of biological materials intended for human consumption and consumers of products, are undergoing regular and rapid changes. These changes have an impact on the quality of food products on offer to consumers but also on the type and characteristics of hazards, such as biological or chemical agents, that may contaminate food. Consumers are also changing as society evolves (population aging, immunodepressed sub-populations, shifts in meal habits) and these transformations are leading consumers to change their consumption practices.

### Constantly changing risk factors

Agricultural production methods have moved from market gardening models to modern intensive agriculture over the past half century. From nearby production with local and rapid consumption, we have moved to mass production with widespread, deferred consumption. As a result, a production incident will potentially have more serious consequences given the size of the consumer population that will be affected. An example is the food poisoning outbreak of 2001 in the United States related to melons contaminated by the bacterium *Listeria monocytogenes*. This foodborne illness outbreak led to 13 deaths and more than 60 other cases. Epidemiological surveys found a single source of contamination on a farm in Colorado but the impact was without precedent given the mass distribution to more than 17 different states.

Processing methods have also seen significant changes. New processes and automation for instance mean that we have to adjust our food safety systems. Implementation of high-temperature cooking processes for certain foods, such as chips, potato crisps, or breakfast cereals, can generate compounds like acrylamide, a substance recognised by the International Agency for Research on Cancer (IARC) as a known carcinogen for animals and possibly humans. In 2013, a study on contamination of certain foods by acrylamide was carried out in France by the Directorate General for Competition, Consumer Affairs and Fraud Control (DGCCRF). This study showed that several product types had an acrylamide content greater than recommended values. In 2008, China faced a large-scale scandal concerning milk products and infant formula contaminated by melamine. Although this episode was caused more by fraud than accident, this processing method led to illness in more than 94,000 people. Lastly, intensive use of cleaning agents and disinfectants in the agro-food industry and generalised refrigeration in food processes have contributed to selection of more resistant microbiological agents. Psychrotrophic bacteria or those resistant to high temperatures, as well as antibiotic-resistant bacteria and cleaning product-resistant bacteria, known as persisters, are of concern in the food production sector. Over the last 10 years in France, the National Reference Laboratory (NRL) for *Salmonella* at ANSES has found a significant increase in the number of multi-resistant *Salmonella* Kentucky isolates from the food chain, specifically with resistance to fluoroquinolones, antibiotics that are therapeutically important in human medicine.

World Trade Organization agreements and the European single market today enable free circulation of food products. EU food imports and exports have doubled since 2005 and the globalisation of trade in raw materials and food products has had enormous consequences on food safety. The 2013 horse meat scandal whereby horse meat was sold as beef shows the complexity of supply, transport, and processing networks which are known to be risk factors given the differences in legislation and regulations between states. Likewise, in 2012, sale of strawberries from China to school canteens in Germany resulted in infection of more than 11,000 school children by norovirus.

Rapid changes to food production and processing methods and globalisation of trade have significantly altered food consumption habits. Changes in eating habits concern both ready-to-eat food preparation processes and the development of collective catering and/or fast food. A clear example is the exponential growth in the consumption of raw food products such as sushi, carpaccio or raw vegetables. These new consumption models are not without safety risks since cooking is a method of controlling and eliminating microbial contamination. This is particularly true for raw fish in which the prevalence of *Anisakis* contamination, a specific parasite of fishery products, ranges from 7 to 75% depending on the species. Back in 2003, the French Institute for Public Health Surveillance estimated the incidence of anisakiasis to be eight cases per year in France on the basis of data from 1985 to 1987. Considering the increased consumption of raw fish in France and although it is a rare parasitosis, the incidence of anisakiasis is very likely to increase and must be monitored.

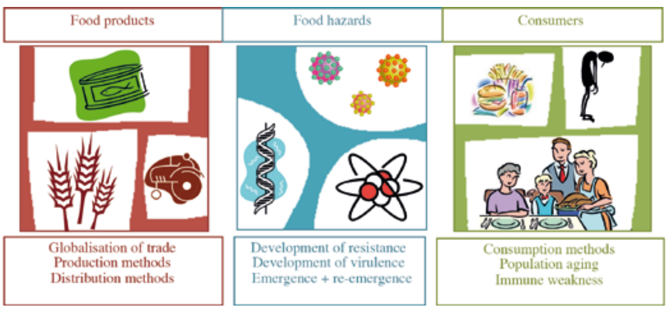


**Figure 1: Typology of changing risk factors in food safety**

# Point of view



All these changes in risk factors (summarised in Figure 1) can be clearly illustrated through one of the most significant food safety crises in Europe in the last few years. In 2011, Germany faced a serious foodborne illness epidemic that involved the infection of nearly 4000 people, with more than 50 deaths. This crisis had wide-ranging health impacts but also an economic impact with the loss of more than 1 billion Euros for the fruit and vegetable sector which was wrongly incriminated in the outbreak. The epidemic was mainly due to:

- fenugreek seeds produced in Egypt, exported to Europe, and sold mainly in Germany (12 cases were also identified in France following consumption of these seeds).
- contamination of seeds by a new strain of *Escherichia coli* O104:H4 which was originally a non-virulent strain (entero-adherent *E. coli*) but that acquired virulence and resistance factors (enterohaemorrhagic *E. coli*).
- development of a new pattern of consumption of germinated raw seeds that mainly affected young adult female consumers who were sensitive to this type of consumption.

## Given these changes, how should we adjust the tools we use?

What would be the best approach to deal with hazards that are increasingly virulent or resistant, use of inputs in agricultural production that are more and more complex, higher diversity of sources and quality of raw materials for processed food products, and changes in consumption practices that disrupt our food safety management and control systems?
To minimise the impact of these changes on the effectiveness of our risk factor analysis systems, it is particularly important to adjust our monitoring systems. Although early detection of alert signals and effective traceability are a good starting point, these systems must move beyond the national perimeter to integrate into international systems for rapid exchange of information and contact between countries. The type of information generated and exchanged must also evolve to better describe the characteristics of hazards and epidemiological situations. This information, whether it comes from monitoring of the environment, animals, human illnesses, adverse effects (toxicovigilance, nutrivigilance, etc.), foodborne illness outbreaks, or foodstuffs (French Observatory of Food Quality (OQALI), monitoring and control plans), must be brought together and meta-analysed to extract all relevant knowledge to help in controlling health risks.
Analytical technologies provide us with tremendous perspectives. High-throughput genomic approaches and high-resolution mass spectrometry provide us with a vast amount of information, down to the molecular or atomic level, and in biology, this mass of data enriches monitoring of changes in pathogenic strains, their virulence factors, as well as chemical substances and their toxic potential.
The “omic” sciences, referring to genomics, transcriptomics, proteomics, and metabolomics (see box), can be used to closely analyse the effects of a xenobiotic substance of infectious or toxic origin on the body. In particular, these techniques help to study the response of the genome to exposure to these toxic agents (toxicogenomics) but have also proven to be excellent diagnostic methods.

Genomics involves all the analyses of the structure of genomes, i.e. sequencing and identification of genes.
Transcriptomics and proteomics are focused on the functioning of the genome, particularly transcription and protein production.
Metabolomics studies metabolites (amino acids, carbohydrates, fatty acids, etc.) found in biological fluids such as blood and urine or in body tissues.

Spectral analysis using NMR spectroscopy or high-resolution mass spectrometry provides increasingly specific information on the presence of a toxic compound in a foodstuff or human sample. These studies can be carried out in a targeted manner when the xenobiotic substance is known, or in a non-targeted way when the xenobiotic compound is not known. They also provide an overall view of the metabolome of a biological sample and of the changes to it caused by an exogenic contaminant.

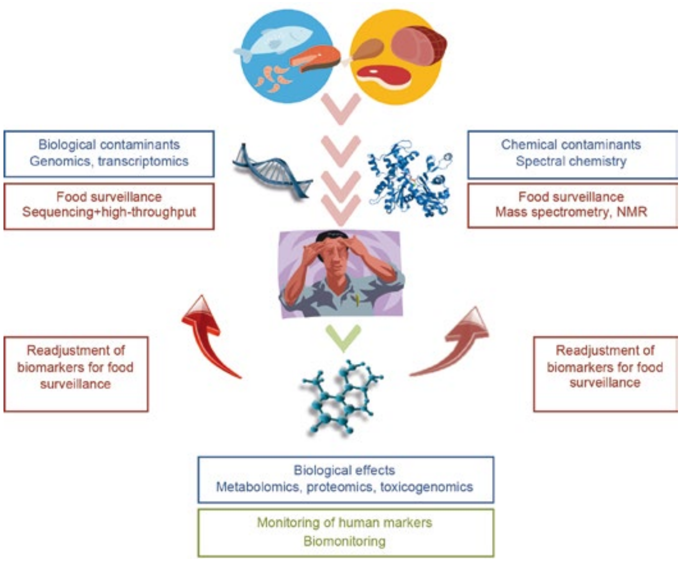


**Figure 2: Contribution of analytical tools to monitoring**

Identification and accurate quantification of a pathogen, chemical substance, products of gene expression for a cell or tissue, and metabolites, help to develop a veritable «infectious or toxicological footprint” of a food substance or food contaminant through screening of the relevant biomarkers.
Data are obtained more and more rapidly and in ever greater quantities, but they must go hand in hand with understanding and interpretation of the information they provide for the specific objective: product testing, risk assessment, or surveillance of emerging risks. The area of bioinformatics has the new challenge of simultaneously analysing a very large amount of data, “big data”, originating from different sources. Interpretation of these data requires the use of powerful bioinformatics methods that are now available and that make it possible to characterise

# Point of view

biological systems in great detail. Progress is also expected to build expert systems that can explain the relationships between a genetic or molecular footprint, a biomarker, and a toxic effect.

Data communication, exchange and analysis technologies have made constant progress over the last few years. The rate of development of these technologies has been a revolution for the area of risk factors. However, we have found that the systems implemented nationally, in Europe, or internationally are still very siloed, informational, and not very interactive.

There are of course information exchange systems, such as RASFF (Rapid Alert System for Food and Feed) at the European level, or INFOSAN (the International Food Safety Authorities Network) internationally, that can be used to rapidly communicate information on the presence of hazards in exported food products or on the emergence of new risks for the consumer, but they focus mainly on regulated hazards that are known and detectable. In the case of the example concerning *Escherichia coli* O104:H4, these systems are not particularly effective in dispelling doubts about a hazard that is difficult to characterise.

A number of initiatives have recently been launched in Europe to better exchange and analyse the information needed to prevent food safety risks. Under the impetus of the European Commission, the European Food Safety Authority (EFSA) is considering setting up genotype and phenotype characterisation databases for bacterial strains found in foods in Europe. The first databases will be for *Salmonella*, *Listeria monocytogenes* and enterohaemorrhagic *E. coli*. These databases will be connected to those of the European Centre for Disease prevention and Control (ECDC) in order to establish relationships between human clinical strains and food strains. Hopefully this tool will be able to prevent diffusion of emerging virulent bacterial clones, to implement suitable control tools, and to deal with the source of the pathogen as rapidly as possible.

Another important initiative is that managed by the emerging risks unit of EFSA, known as EMRISK, which set up as of 2010 an exchange network on emerging risks with partner organisations in the Member States and non-EU countries. EMRISK is tasked with evaluating and developing tools to detect emerging risks in human food and animal feed. It is developing a computer-based collection and analysis tool for metadata available on the internet. This holistic approach relies on information concerning patient reports and food contamination, but also from other areas and disciplines such as economics, international trade, climate change, and human factors, or specific knowledge about supply chains, distribution zones, and production lines, and knowledge on livestock farming and plants. Preliminary analyses carried out with this tool have shown that it is able to detect signals very early on, but its development must be pursued to cover additional media, geographic areas, and "expert" databases.

In a context of changes to food systems, public- and private-sector players, managers and scientists have a broad range of innovative and powerful tools. "Omic" sciences, spectral analysis, and meta-analysis of increasingly large amounts of specific data are making it possible to adapt our surveillance tools and to adjust our management and control systems in the area of food safety. Technical tools and related expertise are being implemented gradually but, much like in the area of globalisation of trade, the efficiency of surveillance systems will only be optimised if there is greater sharing of information and data, paving the way for future collaborative projects.