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Assuring safety in the food chain

A European research priority

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Directorate-General for Research
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Preface

In Europe, production and consumption of food has always been central to society and buying, preparing and eating food have always been considered wide social practices. Accordingly, food research has matured to become an increasingly multidisciplinary science.

At the heart of any food-related implication, the European Union considers the consumer and/or citizen the key stakeholder in the total food chain "From fork to farm".

In order to meet the increasing demand for food quality and safety, the EU Research Framework Programmes reflect the increasingly complex dynamics governing the field and provide a unique and complementary perspective on food science.

Particularly, with this booklet an effort has been made to explain what is being done with EC funds for food safety research. The focus is not on individual success stories but rather on the approach of a programme and its instruments meant to contribute to achieving the European Research Area.

Understanding food safety along the food chain - from the dining table to the farm - is a continuous challenge that can only be addressed through scientific research. To reach this objective the European Commission's Directorate of Research invests and mobilises significant amounts of resources through its framework programmes.

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DG Research
Unit E-3: Food-Health-Well-being
Directorate E: Food, Agriculture and Fishery, and Biotechnology

TABLE OF CONTENTS

Food safety: a **European research** priority

Food is life. From the smallest amoeba to the tallest redwood tree, all living beings require nutrients to survive and thrive. The need for nourishment is a preoccupation that humans share with all other species; it is one of the concerns that lie at the core of all existence. And once food is available, the very next question is whether it is safe to eat.

This observation holds true in today's modern societies just as it did at the dawn of time, remaining as relevant for urbanites armed with shopping trolleys as it probably was for their hunter-gatherer ancestors. And rightly so. While most consumers in the EU have access to abundant food supplies of unprecedented quality at affordable prices, ensuring the safety of these supplies involves constant vigilance at all levels.

THE STAKES ARE HIGH

Assuring food safety is, first and foremost, a public health imperative and an intrinsic aspect of food production.

Safeguarding the quality of Europe's food is therefore not just a commitment to consumer health; it is also an investment in the economy.

This, in turn, feeds into the development of state-of-the-art tools and safety processes, Food safety, as an innovative area in its own right, thus contributes to the emergence of a knowledge-based economy in Europe.

This is a vast, ambitious area of investigation.

A COORDINATED RESPONSE, BASED ON RESEARCH

New insights pushing back the boundaries of the science of safe food can help to fine-tune the EU food safety policy, further increasing its effectiveness. Bearing in mind this objective, the European Commission has been funding research in this field for many years through the previous and the current research framework programmes.

FOOD SAFETY IN FP6

The European Community's Sixth Framework Programme for research and technological development (FP6) was set to change this. Under the heading 'Food quality and safety', FP6 supported R&D activities aiming to boost the quality and safety of Europe's food in a bid to improve the health and well-being of Europe's consumers — and boost the development of the food industry at the same time. Altogether, 181 projects were funded with a total amount of EUR 751 million.

The 'Food quality and safety' programme introduced new scientific areas, hereby significantly extending the scope of the EU's support for research. It covered eight scientific areas flanked by a broad range of specific support actions:

1. Environmental health risks
2. Epidemiology of food-related diseases and allergies
3. Impact of animal feed on health
4. Impact of food on health
5. Traceability processes along the production chain
6. Methods of analysis, detection and control
7. Safer and more environmentally friendly production methods and technologies
8. Total food chain.

FP6 emphasised the need for a collaborative, multidisciplinary approach to complex challenges such as food safety, calling on project consortia to assemble the full range of expertise required to address the task and highlighting the potential contribution of research-intensive SMEs. To facilitate their participation, FP6 earmarked a minimum of 15 % of the total funding allocated across the whole programme for SMEs and set aside additional funds for specific SME activities.

FP6, which ran from 2002 to 2006, funded five types of projects.

Coordinated Actions (CAs) deployed joint initiatives to avoid duplication of efforts in the Member States and develop synergies between existing national and international initiatives.

Networks of Excellence (NoEs) promoted excellence in specific areas by connecting resources, encouraging cooperation and promoting closer integration.

Integrated Projects (IPs) were specifically dedicated to delivering new knowledge, honing the competitive advantage of European industry and support innovation in SMEs by integrating fragmented research activities and resources.

Specific Targeted Research Projects (STREPs) gathered new knowledge or analysed the feasibility of new technologies.

Specific Support Actions (SSAs) contributed to the preparation of new research activities.

More information on the 'Food quality and safety programme', including details of the projects it supported, is available at http://cordis.europa.eu/food/home.html online.

There is still a lot to learn, and Europe's busy food safety research teams certainly have their work cut out for them. Completing the understanding of the origins, mechanisms and pathogenicity of known contaminants and developing powerful tools and processes to hold them at bay would, in itself, make for a comprehensive research agenda. This is particularly true as new methods of scientific investigation, such as genomics (the study of genomes, i.e. the complete DNA sequences of organisms), proteomics (the study of the organism's complete set of proteins) and metabolomics (the study of the organism's metabolic products), are widening the scope.

The complexity of this challenge is further compounded by the fact that food-borne pathogens are a moving target, in every sense of the word. Viruses can mutate and adapt; long-forgotten pathogens may resurface; combined ‚contamination effects or changing food processing techniques have been known to produce unexpected consequences. New pathogens can emerge,

as evidenced by recent food scares involving bovine spongiform encephalopathy (BSE) and H5N1-type bird flu. Weather conditions frequently exacerbate existing food safety challenges, a fact which highlights the need to prepare for climate change. And larger-scale political and economic developments also have their implications. Globalisation in the food chain means that the quality and safety of products sourced abroad should meet European norms and standards.

ADDRESSING CONSUMER CONCERNS THROUGHOUT THE FOOD CHAIN

The EU's 'farm-to-fork' approach to food safety, first introduced by the European Commission's White Paper on Food Safety in 2000 ([1]), highlights the fact that safety requires commitment from all contributors, at all stages. FP6 underpinned this approach, maintaining the emphasis on the need to cover the whole process, but in a reversed order

1 *White Paper on Food Safety,* European Commission, COM (1999) 719 final, 12 January 2000.

WHAT CONSUMERS WANT

A Eurobarometer survey conducted in 2006 ([2]) revealed that European consumers ranked food safety as their number one priority for agricultural policy: 41 % of the respondents felt that the EU should focus on 'ensuring that agricultural products are healthy and safe'. 37 % insisted on the need to secure 'a fair standard of living for farmers'. These two imperatives topped the list, ahead of other major considerations such as 'ensuring reasonable food prices for consumers' (35 %) and 'encouraging quality production' (23 %).

The need to provide enough information about the origin of food and the way in which it was produced and processed was emphasised by one in five respondents — with half of these linking this request specifically to food safety concerns.

2 *Europeans, Agriculture and the Common Agricultural Policy,* Special Eurobarometer 276, European Commission, 2007.

by proposing to tackle the question from the consumer perspective. The resulting 'fork-to-farm' concept, introduced under FP6, places Europe's consumers and their concerns firmly at the centre of research, acknowledging the need to provide safe, high-quality products, promote confidence in these products, and supply citizens with the information they need to make informed choices.

Consumer concerns are complex, and any relevant, comprehensive attempt to address them will draw on a wide range of expertise. No single discipline will be able to provide a definitive answer covering all the multifaceted implications of matters such as animal welfare or genetic engineering — only an inter-disciplinary approach has the intrinsic capacity to address this complexity. It is not surprising, therefore, that inter-disciplinarity stands out as a prominent feature of EU-funded research.

FP6 also widened the geographical scope of the EU-funded research effort, encouraging international cooperation with partners around the world for all of its research topics. In view of the increasing globalisation of the food industry and bearing in mind the substantial amounts of food imported into the EU, cooperation beyond our borders represents a particularly powerful asset in the area of food safety research. Quite obviously, respect for EU food norms and regulations has implications for non-EU fields and farms.

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ADDED BENEFITS — TOWARDS A SINGLE MARKET FOR RESEARCH

In addition to pursuing the obvious thematic objectives, EU-funded research projects contribute to the wider goal of stimulating research and innovation in Europe. EU support enables leading scientists from different countries to pool their expertise in the pursuit of ambitious research goals, permitting such research efforts to build up the critical mass of know-how, data and resources required to advance their goals.

The extensive networks and contacts forged by this type of cooperation are a vital asset across the board of European research. In 2000, the EU launched the European Research Area (ERA) to maximise the outcome of the research conducted in the EU. Measures designed to overcome internal barriers, to avoid fragmentation of effort, data and resources, to eliminate duplication of initiatives and to stimulate the mobility of researchers and knowledge were proposed. These measures aim to optimise and coordinate public research efforts at all levels to support the best research and address major challenges jointly, ensure that researchers can interact seamlessly and benefit from world-class infrastructures, and develop strong links with partners abroad to stay abreast of worldwide progress and contribute to global development.

Stimulating the effective transfer of knowledge to the user is another objective of the ERA.

EU-funded research conquers new ground for food safety

Ensuring that knowledge, once created, can be used effectively to support social, policy and business aims is a crucial part of the innovation process driving the emergence of a knowledge economy in Europe, and thus a precondition for the long-term competitiveness of its businesses. The emphasis on the involvement of industry, in particular SMEs, in the research consortia funded under the current and the previous framework programme reflects this consideration.

NEW HORIZONS — THE KNOWLEDGE-BASED BIO-ECONOMY

This commitment to the transfer and exploitation of knowledge is taking centre stage in the Seventh Framework Programme for research and technological development (FP7), where the scope of food quality and safety research has been extended into the wider framework of the creation of a European Knowledge-Based Bio-Economy (KBBE). The KBBE is the main objective of the 'Food, Agriculture and Fisheries, Biotechnology' research theme, 1 of 10 cooperation themes developed under the current framework programme.

As stated in its annual work programmes ([3]), the activity supported under this heading will bring 'together science, industry and other stakeholders, to exploit new and emerging research opportunities that address social, environmental and economic challenges: the growing demand for safer, healthier, higher quality food and for sustainable use and production of renewable bio-resources; the increasing risk of epizootic and zoonotic diseases and food-related disorders; threats to the sustainability and security of agricultural, aquaculture and fisheries production; and the increasing demand for high-quality food, taking into account animal welfare and rural and coastal contexts and response to specific dietary needs of consumers'. FP7 was launched in 2007 and will run until 2013.

3 Please see http://cordis.europa.eu/fp7/kbbe/about-kbbe_en.html online.

Gathering intelligence

Forewarned is forearmed … and knowledge of the enemy's habits, strengths and weaknesses is an asset in any battle. Food safety is no exception. EU-funded research is helping to push back the boundaries of our understanding of the origins, the nature and the mechanisms of contamination.

Food contaminants are substances which, if present in food in certain amounts, can pose a threat to human health. These substances fall into two main categories: chemical contaminants and microbiological contaminants. Chemical contaminants include substances such as heavy metals, pesticides, industrial chemicals and natural toxins. Microbiological **contamination** is related to living organisms in our food. Note that prions, a new form of infectious agent, are traditionally viewed as microbiological contaminants.

HARMFUL MICROBES

Microorganisms are a permanent feature of our environment. They exist on every surface and we inhale them with every breath. In general we coexist with them, we live in their world and they also — literally — live within us. Most microorganisms are harmless to us; indeed many are of great use, for example yeasts employed in brewing and baking. Other microorganisms, however, are not so benevolent, and present a health risk in the food chain.

Which microbiological contaminants would consumers in Europe be first to name? Notorious culprits such as *Salmonella, E. coli* and the toxoplasmosis parasite would probably rank highly among the responses, which should cover a wide range of bacteria, fungi, parasites and viruses, as well as prions and the various toxins some of these agents may produce. The list is very long indeed.

Chapter 1

ONE OF MANKIND'S OLDEST STRUGGLES

Pick a cheese. Any cheese. Does it seem edible? Your answer will depend on the type of cheese and on your familiarity with it, as some of the more unusual varieties may look perplexing to the uninitiated. Human beings come equipped with a set of basic senses that help us to screen out some of the foods that are likely to make us ill. If a food looks mouldy, smells off and tastes foul, our senses tell us there may be cause for concern. Then again, in the case of cheese, the extravagant mould, the pungent aroma and the ripe flavour may be the main attraction for the connoisseur, and perfectly safe.

Evidently, when it comes to food safety, our senses are unreliable. What's more is that they will only flag up very advanced, major manifestations of a food safety problem. The underlying pathogens are invisible to the naked eye.

History abounds with examples of outbreaks of disease which our senses failed to relate to food. Ergotism, recorded as far back as the early Middle Ages, is one example. Caused by ergot, a type of fungus in grass and grains, this disease (one of the conditions sometimes referred to as 'St Anthony's Fire') plagued Europe until as recently as the 19th century.

Like ergot, many natural food-borne pathogens, such as *Salmonella* and helminths, have tormented mankind since the dawn of time. The 19th century proved to be a turning point, where scientific and technological progress concerning basic sanitation and hygiene helped to mitigate some of the risks. Then again, the industrialisation powered by this progress churned up a whole range of new contaminants. One prominent example dates back to 1845, when lead poisoning attributed to either tinned provisions or the ships' water supply appears to have precipitated the tragic end of the Arctic expedition led by John Franklin. And of course, despite major advances, outbreaks linked to known and emerging pathogens do still occur.

Our ability to name the culprits is a relatively recent achievement. *Listeria monocytogenes,* which coincidentally is often associated with soft cheese and can cause dangerous opportunistic infections in susceptible consumers, was only recognised as a food-borne pathogen as recently as the mid-1980s. The same holds true for the vast majority of others, such as *E. coli.*

Microorganisms were first revealed to us following the invention of the microscope in the 17th century. Our understanding of their nature, their ecology and their relationship with food safety has built up slowly with a major acceleration in knowledge as a result of recent advances in the life sciences — in particular through automated molecular biology techniques which are now replacing the microscope as our primary research tools for studying microbiology.

- *Bacillus* bacteria, including the species *B. cereus,* which can trigger gastrointestinal symptoms, and *B. anthracis,* which causes anthrax (which however is extremely rare, and declining, in Europe).
- *Brucella* bacteria, exposure to which can cause contagious abortion in cattle, and which for humans can translate into the febrile disease brucellosis.
- *Campylobacter,* and *Campylobacter*-like pathogens such as *Arcobacter* and *Helicobacter,* associated with diarrhoeal disease.
- *Clostridium,* a genus of bacteria linked to various forms of food poisoning, including botulism, and colitis.
- *Echinococcus,* a type of tapeworm which can affect many animals including humans. The eggs, ingested through undercooked or unwashed food, develop into larvae in the host and can cause a dangerous parasitic disease.
- *Escherichia coli* bacteria, which are very common in the gastrointestinal tract. However, some strains originating mainly from grass-feeding animals can produce toxins that cause severe infections.
- Influenza viruses, including the strains linked to avian flu.
- *Listeria monocytogenes,* a bacterium that passes unnoticed for most people, but which can have tragic consequences for individuals with impaired or developing immune systems, pregnant women and their unborn children.
- *Mycobacterium bovis,* which causes tuberculosis in cattle and can potentially be transmitted to humans via infected milk or meat.
- Prions, more specifically misfolded prion proteins (PrPSc), the causative agents of variant Creutzfeldt-Jakob disease (vCJD).
- *Salmonella* bacteria, which are most frequently associated with enteric infections. Salmonellosis can produce particularly severe symptoms in patients with fragile immune systems, and comes with a one-in-ten risk of post-infectious complications.
- *Shigella* bacteria, which can cause enteric infections of varying degrees of severity in humans, sometimes followed by joint inflammations and urethritis.
- Staphylococcal enterotoxins, i.e. toxins which can be released into the intestine by various strains of *Staphylococcus* bacteria, causing gastroenteritis.
- *Toxoplasma gondii,* a species of parasitic protozoa responsible for toxoplasmosis.

a mirror of the environment?

what happens when several hazards combine?

This parasite can be transmitted by many animals, although it originates in cats. The infection, harmless to most, can however present major health risks to individuals with weakened immune systems and is potentially life-threatening to unborn children.

- *Trichinella spiralis*, a parasitic nematode sometimes also referred to as the 'pork worm'. Trichinellosis, the disease caused by this roundworm, manifests initially through intestinal problems, which, if untreated, can develop into muscular or neurological symptoms.

- *Yersinia* bacteria, with the subspecies *Y. enterocolitica* and *Y. pseudotuberculosis* specifically linked to food-borne disease. Both cause a form of enteritis occasionally mistaken for appendicitis.

The list of the tiny offenders standing by to invade the food chain makes for chilling reading — and it is by no means exhaustive. It must be noted, however, that food in Europe is carefully monitored to reduce the risk of contamination and minimise the consequences of outbreaks. The aim of further research into familiar and emerging pathogens is to find better, faster tools and approaches to deliver food of unprecedented quality and safety.

Most of the pathogens listed above can be transmitted to humans by animals, either through direct contact or through contaminated food, making these so-called zoonotic diseases a focal point of Europe's food safety strategies. The latest complete survey of infections acquired from food stuffs and animals in the European Union covers 2007 ([1]) and was assembled from data obtained in 27 Member States under the auspices of the European Food Safety Authority (EFSA). The number one cause of zoonotic disease in humans in the EU during 2007 was campylobacteriosis, with 200 507 reported and confirmed cases. This represents a slight decrease in the total number of cases over 2006. In second position was salmonellosis, with 151 985 reported and confirmed cases. Encouragingly, the figures reflect a sharp drop in the prevalence of *Salmonella* since the 1980s and 1990s when it was the dominant form of food-borne illness. This said, valuable as these data are, they are unlikely to reflect the true burden, as food-borne disease often goes undiagnosed and unreported.

One of the characteristics of microbiological contaminants is that, once they enter the food chain, they have the potential to thrive and multiply at some stage — either in the food, or in the eventual host. However, their ability to do so depends on the type of food and on the various conditions to which it is subjected. The factors that encourage or inhibit their development are another crucial area of investigation.

1 *The Community Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents, Antimicrobial Resistance and Foodborne Outbreaks in the European Union in 2007,* EFSA, Jannuary 2009

DANGEROUS CHEMICALS

Germs and parasites are just one part of the equation. The chemical substances to which our food is exposed during production, distribution, processing can also affect its safety.

Chemical contaminants fall into five main categories.

- Agrochemicals, used in agriculture to combat pests and diseases or to increase yields. These include pesticides and herbicides, fertilisers and veterinary drugs (as well as substances such as animal growth promoters, which are now banned in the EU).

- Environmental hazards, and notably:
  - Heavy metals (cadmium, lead, mercury) and arsenic
  - Organic compounds, notably dioxins, polyaromatic hydrocarbons (PAHs) or polychlorinated biphenyls (PCBs
  -

- Natural toxins, such as those produced by fungi or planctonic algae.on which shellfish feed Toxic algal blooms, to name one potential source, are becoming a common occurrence in the coastal marine environment — especially in the summer months.

- Unhealthy substances in packaging materials, which can contain antimony, lead, perfluorooctanoic acid (PFOA), plasticisers or tin.

- Process contaminants, which include substances deposited by the processing equipment (e.g. aluminium, copper, detergents, lubricants, PFOA) and contaminants created by reactions between food constituents themselves during processing or preparation. Examples of the latter include acrylamide, a compound that can form in starchy foods when they are heated .

The harmful effects attributed to several of the compounds listed above include endocrine disruption. Endocrine disruptors, which mimic hormones, affect the function of the hormone system. They are thought to be linked with a range of conditions including cancer, cardiovascular disease and reproductive disorders, and more recently also with obesity.

Beyond the actual nature of these chemical contaminants and their implications for human health, further research efforts focus on their interaction throughout the food chain, which adds another layer of complexity. Studies have suggested, for example, that combinations of some neurotoxicants may generate levels of toxicity in excess of the sum of those associated with the individual substances. Methyl mercury and PCBs, which are often ingested together, are one such combination. This observation raises a whole

will food-borne pathogens automatically make you ill?

barrage of questions. What happens, exactly? Who is affected? What are the risks if safe levels of these substances combine? And, most importantly of course, what can be done about it?

FROM CONTAMINATION TO DISEASE

Unless appropriate processes are in place, contaminants can enter the food chain at any stage of the production, packaging, transport, storage or preparation, affecting the quality of the food and jeopardising the health of the consumers. EU-funded research is helping to establish precisely how this happens, how it affects human health, and how contamination and adverse effects can be prevented.

Will food-borne pathogens automatically make you ill? The short answer is, it depends. On the contaminant, on the degree of contamination, and on you, among other things. The state of your immune system, your age, your diet and your susceptibility to specific diseases are some of the factors that can influence your body's reaction to contamination.

Healthy intestinal microflora strengthen the immune system and can help to mitigate the body's reaction to food-borne pathogens. The friendly bacteria which colonise our intestines are powerful allies in the fight against a range of diseases. Investing in their well-being, for example through a balanced diet and regular exercise, is always a smart move. A range of new products specifically developed to promote gut health also seems promising. They include prebiotics, i.e. nutrients for our microscopic defenders, and probiotics, i.e. living microorganisms notably found in fermented milk products that contribute to the microbial balance of our intestines.

Of course, much depends on the nature of the contaminant. Some contaminants are pathogenic even at very low levels, whereas other agents will only cause disease at very high levels of contamination. What's more, different strains of individual pathogens may be considerably more virulent (likely to cause disease) than others.

A MOVING TARGET

Understanding the nature and the health implications of known food pathogens is a complex task in its own right, but it is just one aspect of the broader food safety challenge. New pathogens can emerge at any time, and long-forgotten threats can resurface, which means that ensuring food safety will always require vigilance and forward thinking.

For example, brand new pathogens — in particular harmful varieties of previously innocuous species — can develop through transfer of virulence factors from one species to another. In general, the evolution of pathogen ecology can be extremely dynamic through random mutation as well as genetic exchange. Moreover, overuse of antibiotics can trigger the development of resistant strains.

Changes in microbiological ecology can generate new pathogens, as can new production and processing techniques and changing consumption patterns. Europe's recent fascination with ready-to-eat meals is one of these changes, and has opened up a whole new area of scientific investigation.

Some of the better-known examples of recently emerged hazards include prions and the H5N1 bird flu virus. *Cryptosporidium parvum,* a parasite which may not make headline news but which can cause severe gastrointestinal symptoms, is another pathogen that has increasingly made its presence felt in the past two decades or so. *C. parvum* is associated with contaminated drinking water as well as reservoirs such as lakes, rivers or swimming pools. Like other waterborne pathogens, it can enter the food chain at various stages. EU funding under FP5 allowed experts from six Member States to collaborate on an in-depth analysis of this pathogen and the associated health risks, and the development of isolation and detection methods.

Global trends and broader socioeconomic and political developments also have food safety implications. Climate change is one of the most obvious examples. Changes in temperature and rain patterns are expected to mitigate some pathogens, while favouring others and potentially helping some to spread to new areas. Globalisation implies that the safety of our food may be affected by the resources, environmental conditions and processing practices of countries where EU regulations do not apply.

These are just some of the factors which could facilitate the emergence of new forms of food-borne disease. Following up on these leads alone will involve a daunting research effort — and many new considerations may arise along the way. Clearly, complacency with regard to food safety will never be an option.

A EUROPEAN FACT-FINDING MISSION

FP6 support has enabled research teams across the EU to advance our understanding of the contaminants, the mechanisms of contamination and the implications for our health. Specific areas of investigation included the epidemiology of food-related diseases and allergies, the impact of animal feed and food on human health, and environmental health risks. This effort to complete the knowledge of biological and chemical food contaminants required to combat and contain them effectively continues under FP7. There is always more to learn.

The insights delivered by the vast range of EU-funded projects exploring this particular area help to inform European food safety policy, feeding into the fine-tuning of regulations and procedures. They also contribute to the development of new tools and techniques to assure food safety along the complete food chain, securing the trust of Europe's consumers and bolstering the competitiveness of the European food industry.

Less talk, more action?
Read up on the following projects for examples of EU-funded research in this area.

ATHON	Assessing the toxicity and hazard of non-dioxin-like PCBs present in food
DEVNERTOX	Toxic threats to the developing nervous system: *in vivo* and *in vitro* studies on the effects of mixture of neurotoxic substances potentially contaminating food
DIEPHY	Dietary exposure to polycyclic aromatic hydrocarbons and DNA damage
EARNEST	Early nutrition programming — long-term follow-up of efficacy and safety trials and integrated epidemiological, genetic, animal, consumer and economic research
F AND F	Food and fecundity: pharmaceutical products as high risk effectors
HEALTHY-WATER	Assessment of human health impacts from emerging microbial pathogens in drinking water by molecular and epidemiological studies
HEATOX	Heat-generated food toxicants, identification, characterisation and risk minimisation
IMMUNOPRION	Immunological and structural studies of prion diversity
PCVD	Studies on the epidemiology, early pathogenesis and control of porcine circovirus diseases (PCVDs)
PHIME	Public health impact of long-term, low-level mixed element exposure in susceptible population strata
PIONEER	Puberty onset — influence of environmental and endogenous regulators
SAFEWASTES	Evaluating physiological and environmental consequences of using organic wastes after technological processing in diets for livestock and humans
STRAINBARRIER	Understanding prion strains and species barriers and devising novel diagnostic approaches
ZINCAGE	Nutritional zinc, oxidative stress and immunosenescence: biochemical, genetic and lifestyle implications for healthy ageing

Details and contact information for these and all other FP6 food safety projects:

- http://cordis.europa.eu/food/projects.htm

Information on FP7 food safety projects:

- http://cordis.europa.eu/fp7/projects_en.html (Theme: FP7-KBBE)

Assessing the **risk**

Food-borne contaminants can cause disease, but the likelihood of this happening depends on a range of factors. These include the quality of the host organism's defences as well as the virulence or toxicity of the contaminant. While it is impossible to produce food that is entirely free from substances that could, at certain levels and under particular circumstances, potentially be harmful, products that are unfit for consumption cannot be allowed to enter the food chain. How do we know how much is too much?

'All things are poison and nothing is without poison, only the dose permits something not to be poisonous', as the physician and alchemist Paracelsus pointed out in the 16th century. The father of toxicology was explaining that any substance taken to excess can be harmful. After all, it is possible to overdose even on water.

Of course, in itself, this statement is hardly reassuring. Consumers expect their food to be safe; they expect the legislator's definition of safety to be based on a thorough understanding of potential risks and to reflect a genuine commitment to a high level of public health, and they expect access to the relevant facts to make informed choices.

The EU's General Food Law, recognising the need to base food safety measures on sound science, breaks risk analysis down into three interrelated components: assessment, management and communication. It calls for risk assessment to 'be undertaken in an independent, objective and transparent manner, on the basis of the available scientific information and data'. It further specifies that food safety assessments must take account not only of the probable immediate, temporary or long-term effects on the consumer, but also of the impact on subsequent generations, in addition to probable cumulative toxic effects and the particular health sensitivities of the targeted consumer groups.

Most importantly, by subscribing to the precautionary principle, the General Food Law provides

sufficient leeway to allow for provisional risk management measures in cases where health risks are suspected but analysis of the available scientific information is inconclusive. This said, it stresses the need for such precautionary measures to be both proportionate and temporary, calling for a comprehensive risk assessment exercise to be performed within a reasonable time frame to eliminate the underlying scientific uncertainty.

Clearly, accurate information is crucial. To ensure that food safety provisions do not become a strangulating burden to the food industry, measures should remain proportionate to the actual risk, safeguard the breadth of the options available to the consumer, and avoid restricting the free circulation of goods unnecessarily.

Through its framework programmes, the EU contributes to the development of sound tools and processes designed to determine the harmful dose of contaminants, assess the risks they represent, and correlate these with the benefits of the affected foodstuffs.

Unfortunately, risk assessment is a very demanding task, and reliable data can be difficult to obtain. This is particularly true when it comes to dose response. While it may take more than 100 million cells from one pathogen to cause illness in a person, the equivalent infectious dose of a more virulent pathogen may be as low as 10 cells. And, to complicate matters further, certain strains of specific pathogens can be considerably more virulent than others.

The key is behaviour: finding out how bacteria behave in a particular environment provides more useful information than just knowing the total numbers of pathogens present. If *E. coli* or *Listeria* is detected in a product, this may not represent a food safety issue in itself, depending on the strain. Moreover, the usual cooking practices are sufficient to kill the invaders. But under the right conditions, a few cells is all it takes. One particular outbreak, for instance, was traced to less than one cell per gram of salami contaminated with a particularly virulent strain of *E. coli*.

RISK ASSESSMENT: FOUR STEPS

Codex Alimentarius, the international reference on standards, codes of practice and guidelines relating to food, was instituted by the Food and Agriculture Organization of the United Nations and the World Health Organization in 1963.

The Food Code defines risk assessment as a 'scientifically based process consisting of the following steps:

1. hazard identification,
2. hazard characterisation,
3. exposure assessment, and
4. risk characterisation'.

To advance the state of the art in dose response analysis, the framework programmes have funded research into innovative approaches. These include the development of mammalian functional cells that can mimic the intestinal tract of pigs, ruminants or poultry. The idea is to study how protective or probiotic bacterial cultures react with an animal's intestinal tract and, most importantly, how pathogens affect this interaction. This research was conducted as part of the wider remit of the PATHOGENCOMBAT project.

CALCULATING EXPOSURE

A wide range of activities dedicated to risk assessment were initiated. Successive calls for proposals encouraged research in this area generally, but also pinpointed the need for research in specific sub-areas. Calls identified a variety of topics, some of which aimed at the development of new and improved risk assessment tools allowing consortia to select their own focus within this general field, while others invited research teams to investigate particular areas of concern. These targeted topics included requests for input on the potential risks associated with novel foods, seafood, heat-treated foods and food products, long-term exposure to non-dioxin-like PCBs or disinfection by-products in drinking water, as well as research into environmental cancer risk with a specific emphasis on nutrition and individual susceptibility.

Of course, beyond the question of the potential pathogenicity or toxicity of a contaminant, there is the related question of potential exposure. How much of a particular contaminant are individuals likely to ingest as part of their diet? Are there additional, non-food sources

ONE MAN'S MEAT…

…is another man's poison. Food allergies mean that a single nut in a bowl of breakfast cereal, a stray shrimp on a salad bar or a crispy stick of celery in a glass of fresh tomato juice could spell disaster for susceptible individuals.

Allergies and asthma are rapidly gaining ground in Europe. Estimates indicate that more than 50 % of the population may suffer from some form of allergy by 2015. Already, as many as one child in three is thought to be affected, and food allergy accounts for some 8 % of these cases.

Precise figures are difficult to ascertain, and the reasons for this sharp rise remain unclear. The soaring prevalence, however, is undisputed — creating a clear mandate for food safety research in this area. FP6 has launched a range of research initiatives carrying out epidemiological studies, investigating the causes and triggers of allergy onset, analysing susceptibility factors, and developing diagnostics and treatments.

to consider for specific substances? To how many different hazards is a person likely to be exposed? And does the combination of these hazards affect the risk of developing a disease?

information on cumulative exposure helps to determine the health risk

In many cases, providing a relevant answer requires drawing on a broad range of interlocking expertise, and ambitious, multidisciplinary projects under FP6 have approached this problem from several angles. Part of this activity centred around probabilistic approaches, aiming to derive realistic exposure profiles from statistical information on contamination and consumption. Comprehensive efforts were deployed to gather the required statistical information and develop tools to determine the dietary intake in different regions and population segments. Collecting and collating information is also key to research into specific diseases. Assembling and completing previously fragmented sets of data provides a critical mass of information for the analysis of rare risk factors, an opportunity more specifically used by one of the research teams backed by FP6 to advance the understanding of the reasons for the rising incidence of non-Hodgkin's lymphoma.

Other projects focused on determining the actual level of contamination in the body. This can be tricky, as many contaminants are metabolised or transformed upon ingestion and, of course, many are eliminated over time. However, they do leave traces, such as metabolites or particular lesions, which can be specific to individual contaminants. These are referred to as biomarkers. Identifying potential biomarkers and proving their relevance as a diagnostic and predictive tool is a complex, lengthy process. The potential, however, is enormous, both in a public health risk analysis context and in health care.

The work of one particular Network of Excellence demonstrates this point particularly well. The ECNIS project, which brought together 24 partners from 13 Member States, used biomarkers to study environmental cancer risk and the ways in which diet and hereditary factors reduce or compound this risk for the individual. The information generated by this project may contribute to the formulation of functional foods reducing the risk of DNA damage and cancer.

In another Network of Excellence, 24 research groups from 9 EU Member States joined forces to study the effects of chemical contamination, and more particularly endocrine disruptors, on human health. Understanding the total dose

to which individuals are subjected, from all possible sources including food, the environment and lifestyle, was a necessary starting point. As a consequence, the CASCADE team's combined know-how has fed into the identification of biomarkers and the development of cell-based and animal monitoring systems that have helped to advance the understanding of human exposure and the related risk.

As part of the wider remit of this project, these insights permitted the development of a large number of novel food testing techniques and systems. These include tests to show whether the presence of chemical contaminants can affect endocrine signalling pathways, and new *in silico* models that can screen chemicals for potential risk. *In silico* or computational biology is showing great potential as a complement to *in vivo* and *in vitro* trials, as it provides a means of undertaking bio-simulations and of dealing with the massive flow of data produced by modern experimental approaches in the food sector. The development of new biological hypotheses for web-lab research on complex biological systems has the additional advantage of reducing costs, lead times for product development and the need for animal testing. Novel analytical methods and procedures were also developed for determining selected chemical contaminants in food, using chromatographic techniques based on mass spectrometry and assays for nuclear receptor-activating compounds.

UNDERSTANDING THE PROS AND CONS

Managing the risks associated with specific foodstuffs involves a thorough understanding of the potential problems, but also of the consequences of the various strategies and scenarios addressing these problems. Seafood is a case in point: while the intrinsic nutritional value of shellfish is generally acknowledged, so is its potential vulnerability to a range of microbiological and chemical contaminants. Experience shows that, with the necessary precautions in place throughout the food chain, which include monitoring of the production environments notably by conducting bacterial analyses and testing for toxins, and subsequently

EUROPE'S RISK ASSESSOR

The European Food Safety Authority (EFSA) assesses the risk linked to food and feed on behalf of the EU, providing independent scientific advice on existing and emerging risks. The research supported by the framework programmes flanks the Agency's comprehensive approach by conducting analyses of specific hazards and developing innovative risk assessment techniques, processes and models — for the benefit of Europe's consumers, but also to bolster the long-term competitiveness of the EU's food industry.

- http://www.efsa.europa.eu

cold storage and hygienic handling of the product, this risk is manageable. Vast amounts of shellfish are consumed across Europe, generally without ill effects. The cost of more drastic measures would far outweigh their potential benefits.

One particularly ambitious approach to modelling undertaken under FP6 has led to the development of a comprehensive new risk analysis tool which transcends the traditional separation of the underlying risk assessment, risk management and

change has consequences

Cost-benefit analyses assess the implications of specific threats to public health and the various options available to address them. This data informs the subsequent risk management process, providing a sound scientific basis for the choice of appropriate measures. While cost-benefit studies are a necessary component of any risk analysis and have thus featured prominently in a range of EU-funded projects, successive calls for proposals have flagged the need for such research in several priority areas. These include the risks and benefits of increased global trade in foods and food ingredients, and assessments of the health benefits against potential effects of environmental damage to the natural or man-made ecosystems outside Europe.

MODELLING THE RISKS

Many FP6 projects exploring this area took the view that risk assessment exercises should be based on a holistic or real-life approach, instead of focusing on individual risk factors in isolation. They proposed modelling approaches designed to predict risk based on a combination of factors.

risk communication steps. In the proposed tool, these steps are integrated into a coherent model alongside a range of insights from the social sciences. Created in a bid to restore consumer confidence in risk analysis processes, the model proposed by SAFE FOODS, an Integrated Project drawing on the combined efforts of 37 institutions from 21 countries, strives to consider the bigger picture. In addition to a full scientific assessment which encompasses the analysis of potential risks and benefits, it also takes account of economic, social and ethical considerations. These include risk perception and the involvement of all stakeholders, consumer preferences and values as well as any specific barriers to implementation.

THINKING AHEAD

Evaluating the safety implications of changing circumstances is a major component of risk assessment. Change, in any form and at any stage in the food chain, has consequences — some of which could expose products to new hazards or affect the conditions that determine

the behaviour of known pathogens. Whether the change is perceived as a triumph or a tragedy, whether it is welcomed or deplored, whether it is introduced by common consent or imposed upon us, is irrelevant in this respect. The consequences have to be addressed.

or harmful practices, need to be examined carefully to ensure that they do not create adverse effects of their own. Progress means change, and the emergence of a research-driven, innovative knowledge (bio-)economy in Europe will rely on many

assess, manage, communicate

Take eggs. In the EU, conventional battery cage systems will be phased out in favour of so-called enriched cages, floor or free-range systems by 2012. This decision is welcomed with great relief by Europe's consumers, who are deeply committed to animal welfare. It is a major step forward for animal husbandry practices in the EU, which will benefit the poultry and also boost the quality of their products. To ensure a smooth transition, research is aiming to pre-empt any possible food safety concerns. Hens kept on the floor or outside are known to be at greater risk of contamination by infectious agents such as *Salmonella*. Consequently, their products are also at greater risk of contamination by any veterinary treatments used to control these infectious agents. These side-effects can be managed reliably, and research is fine-tuning efficient, affordable ways of doing so.

Measures affecting the food chain, even where they represent progress over obsolete

such measures and changes. Advances in our ability to assess risk reliably and precisely will be a major asset in this respect.

PART OF A PROCESS

Of course, risk assessment is not an aim in itself, but a necessary step for the development of recommendations in view of risk management and policy response. And risk assessment is not a task that can relevantly be carried out in isolation. Dialogue with the various stakeholders, and first and foremost consumers, civil society and producers, is a vital aspect of this process. This interaction allows research teams to correlate their work and their appreciation of the risks with public perception of specific hazards, but also ensures that research results reach all interested audiences and can be transformed into useful, tangible outcomes.

Risk assessment is a central concern of many of the food safety projects funded under the framework programmes. A small selection is provided here, and full details of all EU-funded projects in this area are available online.

BENERIS	Benefit-risk assessment for food: an iterative value-of-information approach
BRAFO	A specific support action to investigate the risk-benefit analysis for food
CASCADE	Chemicals as contaminants in the food chain: a Network of Excellence for research, risk assessment and education
ECNIS	Environmental cancer risk, nutrition and individual susceptibility
EUROLYMPH	Collaborative European action into environmental, nutritional and genetic factors in non-Hodgkin's lymphoma aetiology
EUROPREVALL	The prevalence, cost and basis of food allergies across Europe
GA2LEN	Global allergy and asthma European network
GLOFAL	Global view of food allergy: opportunities to study the influence of microbial exposure
GOATBSE	Proposal for improvement of goat TSE discriminative diagnosis and susceptibility-based assessment of BSE infectivity in goat milk and meat
HI-WATE	Health impacts of long-term exposure to disinfection by-products in drinking water
NEWGENERIS	Development and application of biomarkers of dietary exposure to genotoxic and immunotoxic chemicals and of biomarkers of early effects, using mother-child birth cohorts and biobanks
NOFORISK	Quantitative risk assessment strategies for novel foods
PATHOGENCOM-BAT	Control and prevention of emerging and future pathogens at cellular and molecular level throughout the food chain
PEN	Pathogenic *Escherichia coli* network
QALIBRA	Quality of life — integrated benefit and risk analysis web-based tool for assessing food safety and health benefits
SAFE FOODS	Promoting food safety through a new integrated risk analysis approach for foods
SAFEHOUSE	Analysis and control of egg contamination by *Salmonella* and other zoonotic pathogens after the move of laying hens to enriched cages and alternative housing systems

Details and contact information for these and all other FP6 food safety projects:

- http://cordis.europa.eu/food/projects.htm

Information on FP7 food safety projects:

- http://cordis.europa.eu/fp7/projects_en.html (Theme: FP7-KBBE)

Assuring **safety** along the **food chain**

A favourite dish, a nice glass of wine, chocolate mousse and coffee to follow? Whether you are celebrating a special occasion with a carefully planned meal or just tucking into a bowl of microwave pasta on another busy day, you really do not want to worry about food poisoning. Consumers expect their food to be shielded from contamination throughout the whole process that delivers it to their plate, all the way from the farm where the ingredients were produced.

The EU's legal framework for food safety and the various measures adopted to enforce it are designed to keep produce free of harmful levels of contamination throughout the whole agro-food chain — from the production stage, through processing and distribution, to consumption. They are based on the best scientific information available. This emphasis on a sound scientific basis for policy decisions and for the measures, tools and techniques developed to implement them greatly enhances their relevance and their effectiveness. The ability to anticipate, pinpoint, identify and pre-empt or manage risks reduces the number of outbreaks substantially, and any lapses that do occur can be contained more rapidly and more effectively. The interconnectedness of the various actors along the food chain contributes greatly in this regard.

By creating new knowledge and generating new insights, EU-funded projects help to inform and finetune Europe's policies and to improve the speed, accuracy and reliability of the tools and techniques used to monitor the food chain and manage the associated risks. The mission of these projects is to improve our understanding of the benefits and the hazards linked to food, the implications for our health and the mechanisms by which contaminants enter the food chain. In order to develop practical, innovative means of combating the threat of pathogens, but also to formulate nutritional advice and products that can actively contribute to our health, EU-funded projects draw on the latest technologies and methods of scientific investigation.

The massive cash injections powering this line of research are, of course, not awarded randomly. Successive EU framework programmes set out specific priority areas and define their general objectives. Annual work programmes subsequently translate these objectives into specific topics, inviting consortia to submit project proposals.

ADDRESSING SOCIETAL CONCERNS

The preferences, the attitudes and the concerns of citizens increasingly guide the choice of these research topics. Successive food scares over the past decades have raised the awareness of food safety issues, with growing numbers of consumers exercising their right to influence decision makers and seek out the products that meet their personal criteria. The unprecedented interest in farming practices, for example, but also the deepening commitment to animal welfare, social responsibility, ethics and sustainability reflect this active interest in the way our food is produced.

The health and well-being, the expectations and concerns of industry and consumers were the starting point for all food safety research carried out under FP6. Issues that required investigation were considered in terms of their implications throughout the entire food chain, tracing hazards to the consumer back through distribution and processing to primary production, to the environmental conditions that affect it and even to the quality of the feed. Acknowledging the complexity of the issues involved, all projects were required to co-opt the full range of complementary, interlocking expertise needed to rise to these multifaceted challenges.

Eroding consumer confidence in beef and beef products in the wake of the BSE crisis was one such challenge. As a result of the control measures that were deployed at the time, BSE has meanwhile practically been eliminated within the European cattle herd. But food safety researchers were not about to drop their guard, and further research and development support was needed to restore the beef industry to its former glory.

EU funding has enabled a whole raft of projects to explore this area, pinpointing problems, developing innovative solutions and staking out possible areas for improvement and diversification in order to boost the quality, the safety and the nutritional value of the product. While some of the projects addressed a wide remit that covered the complete food chain, others focused on specific aspects commonly associated with the so-called mad cow disease: prions, animal feed, and the traceability of cattle and their products.

Research efforts devoted to related food chain issues reinforced this large-scale offensive to secure top-notch beef for Europe's consumers. The

cutting-edge research for safer products and processes

objectives include upgrading breeding strategies to promote animal health, developing vaccines and plant-based alternatives to curb the use of antibiotics and other veterinary medicines, tackling helminthic and infectious diseases, preventing epizootic outbreaks, reducing the vulnerability of food and feed chains to pathogenic substances and generally promoting competitiveness and innovation along the agro-food chain. New insights in these areas will also benefit beef production.

Similar comprehensive approaches were devoted to pork and pork products, to seafood, to food from low-input and organic production systems and to various questions linked to genetically modified organisms. Increased consumer involvement will be instrumental to the science of safe food, helping to direct investigations in specific areas and securing feedback on the choices that are proposed to mitigate any risks they may reveal.

ALIGNING WITH CHANGING CONSUMPTION PATTERNS

Europe's determination to ensure the safety of its food constantly presents new challenges for research and development efforts as the underlying conditions evolve. At the consumption end of the food chain, consumer behaviour and attitudes rank highly among the factors driving such changes. Shaped by other options, preferences and constraints, our consumption patterns today are quite different from those of our grandparents.

CONSUMER DEMAND TRIGGERS ACTION THROUGHOUT THE FOOD CHAIN

Food safety challenges often have ramifications that extend throughout the entire food chain, from consumption, distribution and processing all the way back to primary production on the farm. Changing consumption patterns are no exception.

The recent popularity of ready-to-eat meals is a case in point. Products like the pre-packed egg sandwich and fresh fruit salad you just picked up at the supermarket offer ample scope for investigation and upgrade at every stage. They have inspired research teams across the EU to develop innovative approaches to improve packaging, optimise processing techniques, extend the shelf life of a product while preserving its flavour and nutritional value, monitor the conditions under which the product was distributed and stored, and even reduce its environmental impact.

And, of course, beyond the direct challenges of ready-to-eat products, the makings of your meal have also benefited from extensive research. For example, through research efforts targeted at keeping the eggs free from contamination as production methods change, improving the nutritional value of the bread, and checking that the fruit in your salad is as healthy as it looks.

Europe's new-found predilection for ready-to-eat (RTE) meals — chilled dishes marketed for immediate consumption — is one such change. To those of us who lack the time or the inclination to slave over a hot stove, these products often seem like a godsend, a no-hassle solution offering all the benefits of a home-cooked meal. And RTE products certainly have the potential to deliver on this promise. This said, temperature control is known to be one of the critical factors in controlling food-borne diseases. Considering RTE meals are chilled rather than frozen and tend to have a short shelf life, a closer look into their safety was warranted.

research adjusts as markets evolve

FP6 has invested in a range of projects aiming to address the challenges of the RTE revolution. Given the importance of temperature control, one particular line of research has analysed the chilled and frozen supply chain to improve the food's safety and quality. Special emphasis was placed on monitoring, managing and tracing the supply chain. A Quantitative Microbial Risk Assessment (QMRA) model has been developed to predict the level of microbial contamination along the way.

Other projects have focused on packaging. The role of food packaging is to protect food from contamination, and the choice of a particular material affects the shelf life of the product. For products such as RTE meals, which are generally associated with 'as fresh' characteristics, but not with high levels of preservatives, the packaging is crucial. Particularly so as distribution distances and storage times have increased in the food industry, and extended shelf lives are valued. To reconcile these two contradictory trends, active and intelligent packaging solutions have been developed. These notably include modified atmosphere packaging that can scavenge or release certain chemicals to control the packaging environment, or feature microbial control systems.

A third set of projects has investigated the potential of various processing technologies to extend the shelf life of RTE products while preserving the quality, the nutritional value and the taste of fresh foods. Innovative non-thermal techniques were considered (such as photosensitisation, pulsed electric fields, high-pressure homogenisation, and high hydrostatic pressure combined with carbon dioxide atmospheres), as were plasma decontamination and advanced heating technologies (such as ohmic and radio frequency heating).

Another line of research supported by the EU has looked into ways of improving the eco-efficiency of RTE meals — one of the main concerns raised with regard to these products, which can be quite wasteful in terms of resources, produce and packaging. Novel, eco-friendly production methods were developed in an attempt

to limit food wastage, lower energy inputs and reduce the use of water and chemicals.

Europe's growing reliance on imported foods, in response to consumer choice or in the general context of globalisation, is another example of the need to align with changes in demand. Europe sources increasing amounts of food, especially seafood, and feed from third countries, and vast volumes of produce are sent abroad for processing and subsequently returned for consumption. Imported and re-imported foods have become a mainstay of the European agro-food sector.

However, these products are likely to have been subject to production and processing methods that differ from those applicable in the EU, will often have been transported over great distances, and may have been exposed to other types of contaminants. Food imported into the EU must comply with the same standards of safety as European products. Nonetheless, shifting and unfamiliar risk profiles may have implications as these imports enter the food chain at the processing, distribution or consumption stages. Busy research teams around the EU are analysing these complex issues and cooperating with partners abroad to flag up specific challenges and find ways of mitigating the risks.

FOOD PROCESSING TOOLS AND METHODS UNDER THE MICROSCOPE

The example of RTE meals mentioned above highlights the role of processing in extending the shelf life of perishable products, but of course the processing stage plays a central role in the safety of any meal. Strict food hygiene standards must be observed, both in industrial settings and at home. Clean surfaces, clean implements, and clean hands are needed to transform pathogen-free ingredients into pathogen-free meals.

how clean is clean?

EU inspections and regulations aim to ensure that the strictest food hygiene standards are met in the food sector, but there is always room for improvement. New knowledge can uncover ways of addressing potential problems more effectively or more easily. Research can help to identify and disseminate best practice. It can also provide a clearer picture of safety challenges where accurate information may have been lacking.

So, clean surfaces? As usual in food safety, there is more to cleanliness than meets the eye. A surface that looks immaculate may still be contaminated with invisible deposits such as the closely packed assemblies of microorganisms known as biofilms. One fruitful research effort in this area has perfected the use of ultraviolet light to detect these biofilms, proposing a cost-effective and

user-friendly tool that could pre-empt the need for extensive microbial testing. Another has studied bacterial adhesion to determine the strength that is needed to detach bacteria from various types of surfaces. Newly developed laser tweezers were used to optically trap individual bacteria and observe their viability and other characteristics.

Clean implements? The cleanliness of processing equipment is another area that has given the EU's research teams much food for thought. It seems obvious that work surfaces, machines and implements should be spotless and fit for purpose. The reality, however, is that equipment and facilities are not always built from suitable, inert materials, and are not always designed with easy, user-friendly maintenance in sight. FP6 has funded research into this area, which has contributed to major advances in the hygienic design of processing equipment.

Clean hands? Yes please. Most cases of food-borne viral outbreaks, for instance, can be traced to food that was manually handled by an infected operator and was not subsequently heated or treated. The fact that poor hygiene spreads germs is hardly surprising, but it remains a significant risk factor that needs to be addressed in the rules, regulations and recommendations aiming to keep consumers safe. Food-borne viruses were the second most frequent cause of outbreaks of food-borne disease in the EU in 2006, after *Salmonella*.

The choice of the actual processing technique can also have food safety implications. Microwave and alternative heating methods are increasingly used in homes and in catering facilities, and the implications for pathogen survival rates have been studied in detail.

This said, contamination can occur as a result of the processing itself. The heating process, for example, generates hazardous compounds that may be linked to various forms of cancer. Acrylamide is one of these substances. It is primarily associated with starchy foods, where it forms as these are cooked.

However, this fact and the associated health risks were only discovered recently. Reliable, accurate information was needed, and FP6 responded by supporting a highly specialised strand of research to elucidate the underlying mechanisms, study the health effects and issue recommendations on processing and cooking methods that minimise the build-up of these contaminants. While there is no obvious way to completely avoid the formation of acrylamide, the good news is that careful cooking can reduce consumer exposure significantly.

FOOD SAFETY STARTS ON THE FARM

Much effort is deployed to keep food safe on its way to the consumer. There would be little point to any of these measures, however, if the produce was contaminated at the outset. And the potential for contamination at the farm level is considerable.

fighting process contamination

Farm animals are naturally contaminated with a variety of potential pathogens and can transmit harmful microorganisms to other hosts or to the environment. And, as they grow, both livestock and crops are affected by the various environmental conditions to which they are exposed.

The know-how and dedication of Europe's farmers, the comprehensive rules and regulations and the extensive inspection and monitoring activities conducted all help to contain potential problems. However, farming practice in Europe currently provides more concentrated environments for the rapid spread of human and animal pathogens than in the past, and therefore, any problems that do arise could potentially cause considerably more damage. With today's intensive farming operations, the amount of produce, the numbers of livestock or the streams of waste that could be affected are simply larger than they used to be. Quite apart from which, new hazards can arise at any time, and research is always looking for better ways of dealing with old problems. The framework programmes support research into primary production in order to analyse the risk factors and the scope to eliminate or at least minimise them.

A very complex question, which successive waves of projects have addressed from every angle. Starting with the health of farm animals. Under FP6, research efforts devoted to cows and pigs, to chickens, rabbits and goats have studied the quality and safety of their feed, possible ways of controlling and managing the various diseases that affect them as well as any microorganisms they may transmit to humans, and issued recommendations on improving their welfare.

Topics in this area ranged from the diagnosis and control of paratuberculosis, prion diseases and porcine circovirus diseases to the development of vaccines. Effective vaccination strategies are one way of reducing the reliance on prophylactic and therapeutic drugs, limiting the risk of residues in the food chain and pre-empting the emergence of antimicrobial resistance. Possible improvements in aquaculture were investigated along similar lines of enquiry.

And the crops received just as much attention. One major strand of activity focused on the fine-tuning and validation of lower-input and organic production systems, reducing the need for agrochemicals such as pesticides and fertilisers. Healthy soil microecology and plant biodiversity are crucial in this respect, and consequently were studied in depth. Other efforts explored genetic resistance as a tool to control the pathogens affecting plants.

Flanking projects devoted to specific aspects of food safety on the farm and in fisheries, a further strand of activity under FP6 considered primary production systems as a whole, from the control of feed quality to the management of waste. Other teams have approached the design of production systems from which human pathogens, such as *Salmonella* and *Listeria*, are virtually absent. Groundbreaking science combines with the age-old know-how of farming generations to shape the safe, environmentally friendly production methods on which our future will rely.

A BRIGHT FUTURE FOR TRADITIONAL FOOD

Will this emphasis on food safety and hygiene whittle away at Europe's exuberant culinary diversity, limiting consumer choice to a few bland staples?

Of course not. While the regulations aim to ensure that Europe's consumers benefit from the same high standards of food safety throughout the whole territory of the EU, they acknowledge the characteristic variety of our traditional cuisines and regional specialities. Special provisions have been put in place to preserve it. This, however, does not mean that there is no scope for improvement or innovation — if only because consumer preference currently favours products with a limited content of sugar, salt and fat, and because the competition from mass-produced and imported products is fierce.

EU-funded teams are looking into ways of boosting the quality and the safety of produce from traditional production systems. Acknowledging that the small-scale nature of many of the activities in this particular sector often deprives producers of the resources and the time to innovate, one particular line of research strives to develop effective, affordable solutions specifically for SMEs. The remit even includes tailoring solutions to the needs of individual businesses. A celebration of Europe's rich gastronomic heritage, another step ahead for food safety, and an excellent opportunity to transfer knowledge to a target group which innovation policies often find hard to reach.

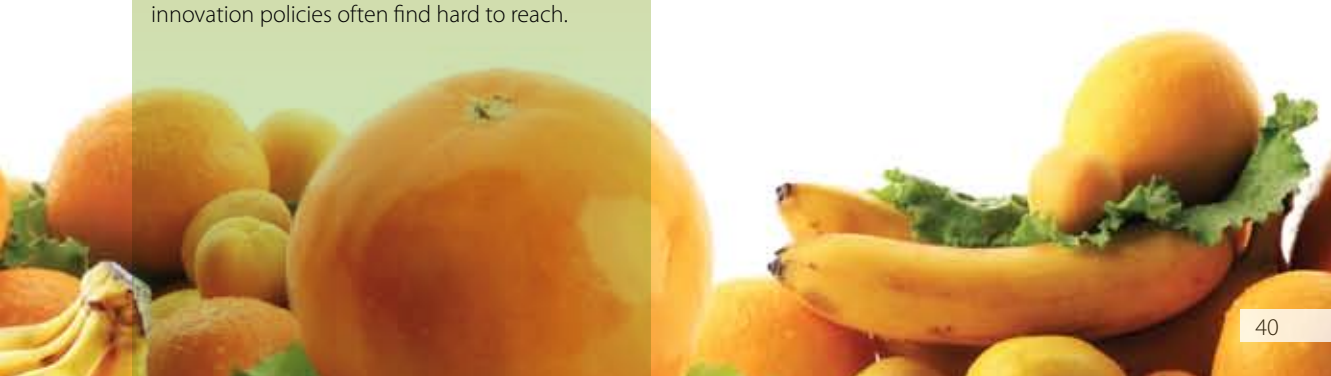
IMPROVING INSPECTION AND TESTING METHODS

Contaminants should not be allowed to enter the food chain in numbers or concentrations that could be detrimental to human health. However, if they do, effective inspection and testing methods are needed to ensure that they can be detected.

Our ability to check that food is free from harmful levels of contaminants, and thus the strength of our last line of defence, rely on our ability to detect these contaminants reliably and quickly. This is by no means as straightforward as it sounds.

At the moment, methods to detect, identify and quantify microbiological pathogens in the food chain are largely based on culture-dependent methods. Samples are taken from food, preparation surfaces or other sources, and any microorganisms that are found are grown in an appropriate substrate or nutrient under defined laboratory conditions for microscopic analysis and visual identification. This traditional method has a number of drawbacks as it can require several days and still return a certain level of false positive and false negative results.

Delays and uncertainty are sufficiently problematic in dealing with known hazards. They become an even greater issue when considering the possibility of encountering pathogens with unknown resistance and virulence traits



— quite a realistic threat in view of the complex, globalised dynamic of the food business.

Better, faster, more precise means of detecting contaminants are sorely needed, and research has risen to the challenge. Recent advances harness polymerase chain reaction (PCR) techniques, a method of amplifying DNA to facilitate analysis and screening, to provide quantitative indications of specific pathogens, potentially down to a single bacterium level of contamination, and combine biosensor applications. Typically, this is a process where the reaction of a biologically active DNA bound to a printed circuit board or silicon chip with a specific pathogen or a pathogen biomarker is monitored via an electrical, electrochemical or optical signal. Luminescent techniques have been developed in which bioluminescent systems from nature — for example, the luciferin-luciferase system found in bacteria, insects and jellyfish — have been integrated into detection systems with pathogen-specific antibodies. They trigger luminescence via their natural signalling systems when a pathogen is bound to the antibody.

Innovative techniques based on microarrays, initially carrying multiple genetic probes but now also extending to protein, antibody or carbohydrate material, are also showing considerable promise. Not only can they detect particular pathogens very quickly, but they can deliver information on virulence, resistance and similar survival characteristics at the same time. Due to their speed, range of application and high throughput, they should prove to be powerful assets in an epidemic or crisis.

Screening techniques based on the use of biomarkers and fingerprinting concepts via new '-omic' techniques, including proteomics and transcriptomics (the study of messenger RNA and the way in which it changes with exposure to specific substances), are also revolutionising the detection of chemical contaminants. Various biosensor technologies have been developed. These include optical biosensors with potential for very high-throughput analysis such as the continuous online analysis of samples, and electrochemical biosensors for affordable, portable applications. The proposed applications for these biosensors range from the detection of heavy metals or of mycotoxins in grain to the measurement of pesticide residue in fruit and vegetables.

Biosensors may also represent a breakthrough in screening for anabolic steroids. The EU has banned the use of these substances as growth hormones for farm animals more than two decades ago, but the current detection methods are too costly and too complex to allow for extensive testing. As a result, only a fraction of the meat entering the market is actually checked. The proposed biosensors are based on a set of biomarkers indicative of abnormal growth patterns. Using samples already obtained for food safety compliance testing, they take only a few minutes to identify batches where steroids may have been involved. Suspect samples can then be selected for further high-level analysis.

REDUCE, REPLACE, REFINE!

By virtue of the Protocol on Protection and Welfare of Animals annexed to the EC Treaty, the European Community and the Member States are committed to paying 'full regard to the welfare requirements of animals' in the formulation and implementation of the Community's agriculture, transport, internal market and research policies.

Research contributes substantially in this respect. FP6 projects, in particular, have explored areas as diverse as the quality of feed, the prevention and treatment of diseases, alternatives to antimicrobials, best practice in breeding, and the complex considerations related to religious slaughter. The knowledge created by these projects will feed into the development of innovative products, techniques and processes that will benefit the welfare of Europe's farm animals directly or indirectly.

And Europe's consumers welcome these developments. Well-kept animals produce better, safer food, and efforts in this area bolster consumer confidence in European agriculture. The Eurobarometer survey on *Europeans, Agriculture and the Common Agricultural Policy*, conducted in 2006 ([1]), confirmed that Europeans feel strongly about animal welfare. More than 80 % of the respondents saw non-compliance with welfare standards as a perfectly good reason to reduce subsidy payments to farms.

But the farm is not the only context where animal welfare is under scrutiny ([2]). In 2005, for instance, more than 12 million animals were used for experimental and other scientific purposes in 25 Member States. European research is actively seeking ways to replace, reduce and refine the use of animals in safety and efficacy evaluations. This emphasis is reflected in the objectives of many of the food safety projects funded under FP6, which have delivered a range of promising alternatives. These include *in vitro* techniques as well as the *in silico* models used in computational biology to simulate biological processes.

1 *Europeans, Agriculture and the Common Agricultural Policy,* Special Eurobarometer 276, European Commission, 2007.

2 *Fifth Report on the Statistics on the Number of Animals used for Experimental and other Scientific Purposes in the Member States of the European Union,* COM(2007) 675 final, European Commission, 2007.

keeping track of food products…

The changes in gene regulation that occur through contact with chemical contaminants provide other angles of attack for the detection of many chemical contaminants, notably through the use of gene array or gene chip technologies. Research is under way to fine-tune these technologies and reduce their cost. Advances in gene profiling are expected to contribute to this development. Profiling could also help to test new or currently unregulated substances and flag up potential health issues by comparing the way in which these substances affect gene expression to the effects of known contaminants.

Other technologies, like the 'electronic nose', were engineered. They rely on the fact that microorganisms produce a range of volatile compounds, such as alcohols, that often represent a characteristic fingerprint. Specific technologies could be based on metal oxide sensors, conducting polymers, mass spectrometry or other techniques. Once optimised for a particular food matrix such systems offer the prospect of near real-time or online detection.

The above-mentioned techniques for detection of pathogens have been subject to international validation and the production of standard protocols.

Powerful innovative detection techniques will not just boost our ability to corner the contaminants, but will also help to scale back animal testing. The detection of biotoxins in seafood, where mouse-based bioassays are commonly used, is one area were animal testing may soon become obsolete.

Considering the potentially catastrophic effects of biotoxins on human health, the need for testing is obvious, but alternatives to animal experimentation are eagerly anticipated. Particularly so as the current bioassays, which are hard to reproduce, expensive and complex without being toxin-specific, have severe limitations. European research is advancing the state of the art by developing new tools. Current options include user-friendly biosensors, point-of-care chip and dip stick or card test assay methods, and a reference multi-toxin detection method based on liquid chromatography-mass spectrometry techniques. Generally speaking, *in vitro* methods are suitable for many chemicals and can help to reduce or eliminate the need for *in vivo* testing — if only by prioritising cases where further testing is required.

Advances in sample preparation using innovative techniques, such as microwave-assisted and pressurised liquid extraction, and aptamers (DNA, RNA or peptide molecules that bind to specific target molecules), are expected to further reduce the time and the cost involved, providing faster and cheaper methods for high-throughput screening. The success of such high-tech approaches does, however, depend to a very large extent on the relevance of the selected samples. Contaminants are not necessarily evenly distributed in a particular batch or consignment, especially in the case of bulk commodities. The

food safety projects supported under FP6 have also delivered new insights into efficient sampling techniques. We may not have quite reached the stage where hazards have nowhere to hide, but we are certainly limiting their options.

ENSURING TRACEABILITY

Exacting standards, strict monitoring and constant vigilance have helped to achieve an unprecedented level of food safety in Europe, and considerable efforts continue to be made to improve on this achievement. However, it will never be possible to completely exclude the possibility of hazards entering the agro-food chain. Where contaminated products are spotted, information on their origins is vital to ensure that the source of the contamination can be traced, that any other products that might be affected can be identified, and that the relevant batches can be withdrawn or recalled swiftly and effectively. Traceability measures aim to secure this information.

to all types of food that are not covered by specific traceability provisions. It requires businesses operating along the food chain to keep precise records showing where they acquired their stock and to whom they sold their products, and to provide this information quickly should the need arise. More stringent traceability rules are in place for beef, fish, fruit, vegetables, honey and olive oil to enable consumers to identify their origin and check their authenticity. Products involving genetically modified organisms are also subject to special rules, in this case to keep track of their transgenic content and to permit accurate labelling.

The case for traceability measures is obvious, the legal requirements are clear, but the approaches deployed to meet these obligations vary considerably. Successive framework programmes have funded research to improve or integrate existing systems, upgrade them by drawing on the potential of new and emerging technologies, check for vulnerabilities, and harmonise practices for greater efficiency. And, just as importantly, support

. . .from the farm to the fork

The EU's traceability regulations date back to the creation of the Internal Market, but the rules were tightened in the wake of the BSE crisis, which highlighted the need to keep track of individual animals, their feed and their food products throughout the food chain. The so-called 'one step back, one step forward' rule generally applies

was provided to encourage the development of verification methods, extending the scope to validate information about specific types of food.

Research efforts deployed under FP6 have designed innovative approaches in these two main areas of traceability research: the fine-tuning and

integration of logistical systems providing the relevant information, and the development of testing methods to check this information. Specific validation and authentication techniques were proposed for foods as diverse as honey, fish and ham. Drawing on a range of natural tracers in the food and exploring the full potential of modern methods of scientific investigation, these techniques can, for example, trace food to a specific region by ascertaining the precise environmental conditions in which it was produced, or identify particular breeds and plants. The results can then be used to validate or refute the alleged characteristics of the product.

one step back, one step forward

Cutting-edge testing techniques can confirm if a product lives up to its billing, but they can also help to establish if potential buyers have been told the full story. In addition to detection and validation techniques, FP6 has also supported the development of sampling and screening techniques. One particular area of investigation in this respect aimed at the detection of unauthorised transgenic ingredients, which was tackled as part of a wider research remit developing reliable coexistence regimes for genetically modified, conventional and organic crops as well as the related traceability and labelling systems. Further total-food-chain traceability studies were devoted to the accidental or deliberate microorganism contamination of food and feed chains, including bottled water, as well as to zoonotic agents and marine biotoxins in seafood.

Traceability systems can also be extended to provide additional data, for example to document how specific products were handled at various stages. Practical applications proposed under FP6 include an integrated traceability system for chilled and frozen food products, which aims to bolster food safety and reduce waste by documenting storage integrity. A broad, complementary range of expertise from the food safety field, supply chain management, logistics and information technology all combine under this innovative system, which boasts state-of-the-art features such as smart labels and applications based on the global positioning system (GPS) and a geographical information system (GIS). Initially conceived for the seafood sector, it is designed to be transferable to other types of food, such as poultry.

To round off the traceability effort, the framework programmes also support the exchange of best practice and initiatives that involve trade partners around the world in the process. The ability to trace and authenticate products will be an increasingly powerful tool on the road to optimal food safety.

Hundreds of recent projects have conducted leading-edge research into safety along the food chain, but the scope of this publication does not allow for detailed coverage of their outcomes. A representative selection of the activities supported under FP6 is provided below. Many other teams have explored food safety issues and related aspects such as the fine-tuning of low-input production methods, the links between nutrition and health, and the development of functional foods. Details of all EU-funded food safety projects are available online.

ACE-ART	Assessment and critical evaluation of antibiotic resistance transferability in the food chain
BIOCOP	New technologies to screen multiple chemical contaminants in food
BIODET	Networking in the application of biosensors to pesticide detection in fruits and vegetables
BIOTOX	Development of cost-effective tools for risk management and traceability systems for marine biotoxins in seafood
BIOTOXMARIN	Development of novel analytic tools for the detection of marine biotoxins
BIOTRACER	Improved bio-traceability of unintended microorganisms and their substances in food and feed chains
CO-EXTRA	GM and non-GM supply chains: their coexistence and traceability
CHILL-ON	Developing and integrating novel technologies to improve safety, transparency and quality insurance of the chilled/frozen food supply chain
DELIVER	Design of effective and sustainable control strategies for liver fluke in Europe
DETECTOX	Development of a surface plasmon resonance-based biosensor for the detection of lipophilic phycotoxins in shellfish residues
DIALREL	Religious slaughter: improving knowledge and expertise through dialogue and debate on issues of welfare, legislation and socioeconomic aspects
DOUBLEFRESH	Towards a new generation of healthier and tastier ready-to-eat meals with fresh ingredients
EADGENE	European animal disease genomics Network of Excellence for animal health and food safety
EPIZONE	Network on epizootic disease diagnosis and control
EUROMED-CITRUSNET	Safe and high-quality supply chains and networks for the citrus industry between Mediterranean partner countries and Europe
EU-US-SAFE-FOOD	Developing a strategic transatlantic approach to food safety
FEEDING FATS SAFETY	Quality and safety of feeding fats obtained from waste or by-products from the food chain

FEED FOR PIG HEALTH	Development of natural alternatives to antimicrobials for the control of pig health and promotion of performance
HIGHQ RTE	Innovative non-thermal processing technologies to improve the quality and safety of ready-to-eat meals
IMAQUANIM	Improved immunity of aquacultured animals
MED-VET-NET	Network for prevention and control of zoonoses
MONIQA	Towards the harmonisation of analytical methods for monitoring quality and safety in the food chain
NEUROPRION	Prevention, control and management of prion diseases
NOVELQ	Novel processing methods for the production and distribution of high-quality and safe foods
OTAG	Operational management and geodecisional prototype to track and trace agricultural production
PARASOL	Novel solutions for the sustainable control of nematodes in ruminants
PARATBTOOLS	Development of improved tools for the detection of paratuberculosis in livestock, *M. paratuberculosis* in food and for the assessment of the risk of human exposure
PETER	Promoting European traceability excellence and research
PHAGEVET-P	Veterinary phage therapies as alternatives to antibiotics in poultry production
POULTRYFLORGUT	Control of the intestinal flora in poultry for ensuring the products' safety for human consumers
PROSAFEBEEF	Improving the safety of beef and beef products for the consumer in production and processing
Q-PORKCHAINS	Improving the quality of pork and pork products for the consumer: development of innovative, integrated and sustainable food production chains of high-quality pork products matching consumer demand
QUALITYLOWINPUT-FOOD	Improving quality and safety and reduction of cost in the European organic and low-input supply chains
REPLACE	Plants and their extracts and other natural alternatives to antimicrobials in feeds
RESCAPE	Reducing egg susceptibility to contaminations in avian production in Europe

RESISTVIR	Coordination of research on genetic resistance to control plant pathogenic viruses and their vectors in European crops
RHIBAC	Rhizobacteria for reduced fertiliser inputs in wheat
SABRE	Cutting-edge genomics for sustainable animal breeding
SAFEED-PAP	Detection of presence of species-specific processed animal proteins in animal feed
SAFIR	Safe and high-quality food production using poor-quality waters and improved irrigation systems and management
ΣCHAIN	Developing a stakeholders' guide on the vulnerability of food and feed chains to dangerous agents and substances
SEAFOODPLUS	Health-promoting, safe seafood of high eating quality in a consumer-driven fork-to-farm concept
SUPASALVAC	*Salmonella*-free broilers by live vaccine-induced innate resistance to colonisation and invasion and novel methods to eliminate vaccine and field strains
TESTMETEDECO	Development of test methods for the detection and characterisation of endocrine-disrupting chemicals in environmental species
TRACE	Tracing food commodities in Europe
TRACEBACK	Integrated system for a reliable traceability of food supply chains
TRANSCONTAINER	Developing efficient and stable biological containment systems for genetically modified plants
TRUEFOOD	Traditional united Europe food
WELFARE QUALITY	Integration of animal welfare in the food quality chain: from public concern to improved welfare and transparent quality

Details and contact information for these and all other FP6 food safety projects:

- http://cordis.europa.eu/food/projects.htm

Information on FP7 food safety projects:

- http://cordis.europa.eu/fp7/projects_en.html (Theme: FP7-KBBE)

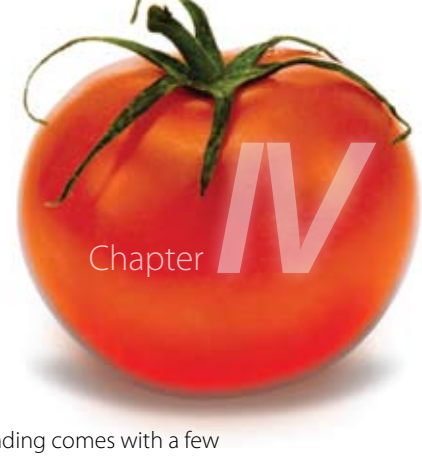
Communicating research **results**

Food safety research addresses issues that matter — to consumers, to industry, to policy makers, to the world. The knowledge created has repercussions at many levels, from the hallowed halls of government, through oak-panelled board rooms and teeming farmer's markets, right into the heart of our homes. Everybody has an opinion, everybody has something useful to contribute, and everybody is affected by the outcomes.

The EU funds food safety research which it expects to produce clear benefits to society, boosting the competitiveness of the European food industry in the process. Hundreds of research projects have been deployed over the years to secure the outstanding quality of Europe's food supplies. The objective extends well beyond ensuring that food is safe to be consumed, although this remains a central concern for food researchers and technicians, and an ambitious target in itself. Among the numerous aims of the research supported by the EU, further investigations aim to ascertain that diets are healthy, nutritious and eco-friendly, develop functional foods and explore the links between diet and public health.

ENGAGING WITH THE STAKEHOLDERS

The health and well-being of consumers, their expectations and concerns are the starting point for this vast research effort. Once the major issues are identified, these are considered in terms of the underlying risks or implications throughout the food chain. Researchers and public authorities have a precise view of the areas that need close attention, but to fully meet the objective of the EU's framework programmes, their understanding must be correlated with consumer perception. And the best way to explore consumer attitudes is to ask the consumers themselves.



The framework programmes acknowledge the crucial importance of this dialogue. To ensure that the public can provide input on the directions research is taking, project consortia are encouraged to involve stakeholders, such as patient and consumer organisations, from the very beginning — starting with the actual proposal. Teams of EU-funded projects are also urged to address the wider ethical, societal, economic and cultural aspects of their work, for example by bringing in experts from the fields of ethics, law, economy or the social sciences. Research teams do not operate in a vacuum; they are expected to take note of the wider implications of their work.

The public, in their capacity as citizens, consumers or patients, are not the only stakeholders with clear expectations and opinions regarding Europe's food research. From farmers and agro-food businesses to environmental and animal welfare organisations, the range of considerations and insights that can help to shape future research and development activities is vast. A common understanding of the role and the relevance of Europe's research activities can only be achieved through dialogue with these various partners.

Establishing dialogue with stakeholders early on in the process does not just tap a valuable source of input for the project; it also provides an opportunity to open lines of communication, to ascertain the type of information stakeholders would like to receive and to foster their confidence in the process. EU funding comes with a few strings attached, one of them being that projects are required to disseminate their findings and to take measures to stimulate the use of these results by industry, policy makers and society.

This emphasis on the creation, transfer and exploitation of knowledge is one of the key concepts underpinning the framework programmes. In addition to the research projects tackling specific topics on the EU's research agenda, the framework programmes also fund a vast range of Specific Support Actions (SSAs). These SSAs contribute to the implementation of the activities of the work programmes by facilitating the dissemination and exploitation of research results, by supporting strategic objectives such as the consolidation of the European Research Area and by preparing future research and development activities, for example through consumer studies and stakeholder consultation.

ENABLING THE CONSUMER TO MAKE INFORMED CHOICES

Food research topics are elaborated in view of their societal relevance, including the health and well-being of citizens. In some cases, where the implications for consumers are obvious, the public awaits outcomes with bated breath. In other cases, the relevance of individual research efforts to our daily lives requires a bit more explanation.

Communicating research results

Chapter 4

Research projects supported by European funding conduct a range of communication activities to present their objectives and their findings. All projects develop their own approach, selecting suitable means to reach their specific target audiences. But all projects communicate either directly or indirectly through consumer organisations or the media, and in doing so, add to the sum of knowledge available to the public. Goods offered for sale in Europe are subject to exacting food standards and are presumed to be safe, but systematic dissemination of research results enables consumers to build up their own picture of any remaining hazards and make informed choices. Furthermore, comprehensive food labelling ensures that consumers can identify the products that meet their personal requirements.

Risk analysis exercises are another area where the relevance of communication is manifest. Risk communication is the indispensable third component of any risk analysis. It consists of the

WHY FOOD LABELS MATTER

Are you allergic to certain foodstuffs? Do you avoid specific ingredients for religious reasons? Are you a vegetarian or a vegan? Do you try to cut down on food miles? Are you concerned about GMO foods or E numbers? Do you prefer to buy organic? Are you on a diet? Do you want to know where your beef was raised?

If you answered 'yes' to any of these questions, you are likely to be one of the growing number of consumers who examine food labels very closely indeed. You have every right to know what you are buying, and Europe's labelling rules aim to ensure that you can exercise this right.

Labels must list all the ingredients of a product, they must indicate if any of these ingredients are transgenic, and they must specify the origin of some types of food. The latter includes beef, veal, eggs, fish, honey, fruit and vegetables as well as any products where geographical origin is a particular selling point.

Nutritional information must be supplied if the product is marketed as particularly nutritious or if vitamins or minerals have been added. Ionising treatment, if used, must always be mentioned. Additional rules apply for various categories of food, such as baby formula, mineral water, alcohol and diet products.

Producers and manufacturers may add any further information they would like to pass on to the consumer, provided that claims are correct, i.e. underpinned by scientific evidence, and not misleading. The use of the word 'organic' on food labels, for example, is strictly regulated.

exchange of information and opinions about the risk, the risk assessment and its outcomes, and the measures proposed to manage this risk. All relevant stakeholders and interested parties should be included in this process. Effective, transparent communication demonstrating the relevance of the underlying risk assessment and management processes can help considerably in securing cooperation and support in the face of specific risks, whereas unconvincing or insufficient communication will inevitably erode consumer confidence.

giving the consumer all the facts

While the framework programmes actively support the promotion of research results, there can be little doubt that communication activities are a risky business. As the poet Alexander Pope pointed out several centuries ago, 'a little learning is a dangerous thing': information that is presented out of context or inadequately explained can create or perpetuate misunderstandings. This issue presents Europe's research teams with a range of additional challenges. While projects tend to welcome interest in their work, researchers are not always particularly confident about their communication skills.

Europe's consumers, however, have clearly voted in their favour. A Eurobarometer survey conducted in 2007 ([1]) revealed that Europeans are interested in research results, but that they would much rather be informed by scientists than journalists. Some respondents expressed a preference for scientific news from journalists, claiming that they were, on the whole, better equipped to get their point across. Still, the scientists carried the day, as an overwhelming majority perceived their information as more trustworthy, more precise and more objective. To support researchers in this task, appropriate food communication strategies are being considered to spread European policies and initiatives more efficiently.

TRANSFERRING KNOWLEDGE, PROMOTING BEST PRACTICE

The outcomes of Europe's research and development activities in the food safety area are awaited just as eagerly by the agro-food sector. They drive the development of innovative tools and techniques which may well turn out to be a goldmine in their own right. More importantly, however, new tools and techniques help agro-food businesses to improve their

1 *Scientific research in the media,* Special Eurobarometer 282, European Commission, December 2007.

products and processes, and thus to consolidate their position in a competitive global market.

This said, innovation is not a one-way system where researchers create knowledge, and industry exploits it. This traditional, linear understanding is gradually being replaced by a more systemic view, which acknowledges the crucial role of interaction throughout the process in

In identifying and disseminating best practice, research projects provide another invaluable service to the agro-food sector. The EU strives to ensure the same high level of food safety throughout its territory. Rules and regulations, inspection and monitoring are its main tools in this respect, but access to best practice information enables businesses along the whole food chain to raise their game even further.

sharing information with stakeholders in the EU…

bringing the innovative ideas generated by various stakeholders to fruition. The input of agro-food businesses in identifying the needs, their experience and understanding of the sector along with their flair for potential market niches provide guidance and inspiration for EU-funded research. Their involvement in ongoing research projects enables businesses to input directly on studies that are of interest to them and secure support for their own R&D efforts, and it also provides opportunities to test and validate innovative approaches in an actual production environment. Successive framework programmes have particularly encouraged the involvement of research-intensive SME in project consortia.

CLOSE TIES WITH TRADE PARTNERS ABROAD

Europe imports and re-imports food from around the world. This fact inevitably adds an international dimension to research into quality and safety, not least because imported foods must meet the same exacting standards as goods sourced in the EU.

The framework programmes offer ample scope for close cooperation with partners from third countries. This cooperation helps to secure research excellence by co-opting the best expertise available abroad, enables countries and organisations to join

forces in order to tackle problems of shared interest preferably before affecting Europe, and also supports research efforts striving to address specific regional or global challenges as part of Europe's contribution to the Millennium Development Goals.

Under FP6, this emphasis on scientific cooperation is reflected in the impressive international

A SOUND BASIS FOR POLICY DECISIONS

Consumer empowerment, knowledge transfer and dissemination of best practice are just part of the picture. One of the central roles of EU-funded research is to provide the data needed to inform policy decisions, regulations and food safety measures.

…and with partners around the world

scope of many funded projects. Various teams have, for example, networked risk management activities around the globe to keep tabs on emerging hazards, pooled expertise with colleagues in many parts of the world and helped several countries to develop their food supply chains to international standards. Such initiatives produce substantial benefits for all involved — including Europe's consumers.

Under the current framework programme, food safety research is addressed as part of Cooperation Theme 2, dedicated to food, agriculture and fisheries, and biotechnology. The research conducted under this heading is also expected to extend the knowledge base underpinning the Common Agricultural Policy, the Development Policy, the Fisheries Policy, the Forest Strategy and the Forestry Action Plan as well as the Animal Health Policy, and will help to shape Europe's approach to agriculture and trade issues.

FP6 introduced a strong emphasis on consultation, dialogue with stakeholders and the promotion of research results. While all projects funded under the 'Food quality and safety' heading conducted communication activities, a whole range of research projects and Specific Support Actions were explicitly devoted to dissemination. The following selection of projects may tempt you to access the complete catalogue online.

ALCUE-FOOD	From European fork to Latin-American farm: an innovative networking platform for EU-LAC partnerships in food quality and safety R&D
BIOPOLIS	Inventory and analysis of national public policies that stimulate research in life sciences and biotechnology, its exploitation and commercialisation by industry in Europe in the period 2001–2004
BIOPOP	Pilot study on innovative approaches to public communication on life sciences and biotechnology by students and young researchers
BIOPRODUCTS 4 FOOD	Disseminating the results of EC-funded research into food quality and safety to facilitate their transfer and exploitation into new products and processes to improve European health and well-being
BIOSAFENET	Biosafety research communication network
CDEUSSA	European platform for research on the prevention and treatment of coeliac disease: a multidisciplinary approach to integrate basic scientific knowledge in clinical applications and in the food industry
CLONING IN PUBLIC	Farm animal cloning and the public — a project to facilitate a European public debate and to make recommendations on regulation and on guidelines for research and applications of farm animal cloning
CODE-EFABAR	Code of good practice for farm animal breeding and reproduction
CONSUMER-CHOICE	Do European consumers buy GMO foods?
EAGLES FOOD FORUM	European action on global life sciences — food forum
ERMES	European research for Mediterranean seafood
EUROFIR	European food information resource network
EUFOOD4LIFE	European Technology Platform for the agro-food sector: food for life
EUROLATSEA	European research for the Latin-American seafood industry
FEED-SEG	Healthy feed for safety — dissemination of research results of EC-funded research on feed quality
FOOD-N-CO	Cooperation network of national contact points with a special focus on third countries in the area of food quality and safety
FORALLVENT	Forum for allergy prevention
GO-GLOBAL	Global platform on emerging risk in the food and feed chain
GMO-COMPASS	GMO communication and safety evaluation platform

INFOOD NETWORK	Sharing information on food-related environments, safety and traceability aspects among European small-medium farms
INPLISTA	Information platform on international standards for SMEs in the food sector
IRFOS	Integration of European food quality research from producers to consumers
MEDA GO TO EUROPE	Enhancing the participation of Mediterranean countries in the area of food quality and safety in FP7
MREFS	A multimedia repository on European food science: production, quality and safety
MYCO-GLOBE	Integration of mycotoxin and toxigenic fungi research for food safety in global systems
QUALITYMEAT	Survey on the research landscape in the associated candidate countries for monitoring and promoting good quality meat production — the whole food chain, from farm to fork, of poultry and pork meat
POLFOOD	Research and innovation in food technologies — brokering European partnership and transfer of knowledge to Poland by a series of practical workshops
SAFEFOODNET	Chemical food safety network for the enlarging Europe
SAFOODNET	Food safety and hygiene networking within new EU countries and associated candidate countries
SCIENCE 4 BIOREG	Global involvement of public research scientists in regulations of biosafety and agricultural biotechnology
SELAMAT	Safety enhancement of edible products, legislation, analysis and management, with ASEM countries, by mutual training and research
SMES-NET	SMEs networking European food safety stakeholders
TDC-OLIVE	Setting up a network of technology dissemination centres to optimise SMEs in the olive and olive oil sector
TECARE	Transregional cooperative platform for competitiveness in meat research and SMEs
TRAINNET FUTURE	Training network for national contact points and support organisations with special focus on candidate countries in the area of food quality and safety
YOUNG-TRAIN	Training and mentoring young scientists from candidate, associated and Mediterranean countries in a whole food chain approach to quality and safety

Details and contact information for these and all other FP6 food safety projects:

- http://cordis.europa.eu/food/projects.htm

Information on FP7 food safety projects:

- http://cordis.europa.eu/fp7/projects_en.html (Theme: FP7-KBBE)

Staying **one step ahead**

Emerging hazards, fresh insights, shifting circumstances — there will always be new challenges to address and unexpected possibilities to explore in the interest of consumer well-being. In addition to keeping known contaminants in check, food safety research strives to follow up on the merest hint of an unfamiliar threat. And, like all areas of scientific investigation, it is always keen to upgrade its tools and techniques and use these advances to develop better, faster and cheaper products and processes.

Food safety research has played a pivotal role in Europe's efforts to safeguard the health of its consumers and businesses, and will continue to do so for many years to come. In fact, the EU's determination to foster the emergence of a knowledge-driven economy firmly relies on food research, as one of several priority areas of European research and development, to realise its full potential.

Reaching beyond a potentially restrictive focus on the need to avoid disease, which however remains a central priority, food safety research is drawing on its detailed understanding of the intricate links between diet and disease to identify foods that can actively promote our health. Complementing the benefits of a balanced diet, newly formulated 'functional foods' may increasingly enable us to build up our defences against certain types of disease or mitigate their effects.

ONGOING VIGILANCE

This said, the need to watch out for new hazards will remain central to many food research efforts. New contaminants will arise even as solutions to counter familiar hazards are found, mutations could produce highly pathogenic strains of previously low-risk pathogens, and long-forgotten threats could resurface. The face of food-borne contamination is forever changing.

Of course, food safety experts have already pinpointed the likelier sources of future hazards. Pathogens that could evolve into major menaces include today's silent, non-virulent zoonoses as well the various microorganisms that are already endangering individuals with compromised immune systems. Contaminants such as mycotoxins and various toxic, natural botanical chemicals used as food supplements could also rise to the top of the list of suspects.

domino effect of seemingly unrelated actions. In truth, Europe's coffee aficionados have little to fear from mycotoxins. The EU has worked hard on the mycotoxin issue over the past decade, and these substances are now tightly controlled in the food chain.

But new contaminants will appear. The ongoing challenge for European food safety lies in identifying these emerging hazards, analysing

a combination of ingenuity, dialogue and determination

Climate change, globalisation and socioeconomic developments, in general, add to the complex factors that drive the emergence of new threats. It is quite possible, for instance, that fluctuations in the price of coffee on the world's commodity markets could affect the levels of mycotoxin in the product. How? Mycotoxins are metabolites of fungi, which can grow in many types of food, including coffee beans. When prices fall, some coffee-producing countries hold on to their stock in hopes of achieving better prices at a later date. Extended storage can translate into higher levels of contamination, as mould is given more time to do its worst.

This single example, plucked from the broad spectrum of potential fungus-related risks, simply serves to demonstrate the potential

the risks, developing detection tools and methods, and proposing appropriate risk management measures. Early warning systems such as the RASFF are already proving invaluable in this respect. They also boost Europe's ability to respond to a crisis triggered by the accidental, negligent or intentional contamination of food products, should the need arise.

BUILDING ALLIANCES

Researchers cannot tackle the threat of food contamination single-handedly or in isolation. The consolidation of the European Research Area will help to interface previously fragmented approaches, coordinate research efforts between the Member States, facilitate the access

to world-class research networks and infrastructures, and encourage the development of strong ties with partners around the world.

Substantial financial support provided under the EU's framework programmes reflects Europe's commitment to international cooperation. The opportunity to exchange information and expertise with colleagues in the EU and beyond helps Europe's food safety researchers to advance the state of the art. It will remain a major asset.

The opportunity to engage with the various stakeholders represents another such asset. As mentioned in the preceding pages, the EU's food safety research has come to focus primarily on the health and well-being of the consumer. Open and constructive dialogue with consumers and their representatives provides valuable input for Europe's research projects and accelerates the dissemination of their findings.

However, interaction with industry and the agro-food sector is the main driver of the uptake of research results, stimulating the application of new knowledge in innovative tools and techniques, and facilitating the dissemination of good practice. Dialogue with public authorities at European, national and regional level provides opportunities to align the relevant rules, regulations and risk management measures with new research findings and helps to secure the same high level of food safety across the whole territory of the EU.

TRAINING UP A NEW GENERATION OF FOOD SAFETY EXPERTS

What does it take to excel as a food safety researcher? Curiosity, no doubt. A creative mind, a passion for science. Dedication. Attention to detail. And more.

These are fine qualities indeed, which would certainly pave the way to a distinguished career in the field — and in many others. FP7 is supporting through research the development of precisely such attributes and skills an aspiring food scientist or technician will need. This investigation will also look into ways of making careers in food safety more attractive to promising candidates. The aim is to ensure that the next generation of food safety experts is duly prepared for working life, enabling them to fulfil their crucial role on behalf of the various stakeholders at any point along the food chain. In short, to place the future of food safety in capable hands.

TOWARDS A KNOWLEDGE-DRIVEN ECONOMY

FP7 aims to harness the power of this cooperation to address food safety issues in the context of building a European knowledge-based bio-economy. The EU's bio-economy, as defined in the work programme for FP7's Cooperation Theme 2 ([1]), encompasses 'all industries and sectors that produce, manage and otherwise exploit biological resources (and related services, supply or consumer industries), such as agriculture, food, fisheries and other marine resources, etc'.

All research topics related to the production of safer, healthier, higher-quality food, to the sustainable production and use of renewable bio-resources, to the risks of epizootic and zoonotic diseases or to food-related disorders will be addressed under this heading. A total budget of EUR 1 935 million has been earmarked for work in this area.

FP7 was launched in 2007 and will run until 2013. The work programmes covering the early, years of its activity under Cooperation Theme 2 have notably highlighted the need for research into the following key food safety challenges:

- alternatives to sulphites in foods;
- biocides and antibiotic resistance;
- characterisation of nano-particles in the food matrix;
- combined exposure to pesticides;
- analysis of the effects of food processing techniques through exploration of the micro-structure of foods;
- assessment of the risks involved in human exposure to perfluorinated organic compounds in foods;
- impact of climate change on the safety of European and global food markets;
- risk-benefit assessment of food supplements;
- risk-benefit perception and communication in the food chain;
- improvement of refrigeration techniques along the food chain;
- transparency along the food value chain;
- dissemination of research results in the food sector;

1 Work Programme 2010 / Cooperation Theme 2, C(2007)5765, European Commission, November 2007 — see http://cordis.europa.eu/fp7/kbbe/about-kbbe_en.html online.

- enhanced cooperation in food and health, with a view to strengthening the European Research Area;
- sharing of food technology research and development by means of international collaboration.

Beyond these specifically safety-related topics, FP7 supports a broad range of investigations into the links between food and health as well as into sustainable production systems. This research will notably deliver new insights into nutrition, examine beneficial dietary habits in the EU and abroad, explore the scope to reduce the use of veterinary drugs and agrochemicals, and promote animal welfare. The development of innovative, sustainable, affordable and competitive products in these areas will not only help to keep Europe's consumers safe and healthy, but also hone the competitive edge of its businesses.

FP7 will be providing a substantial boost for food safety research in the coming years. While it is too early to report on tangible outcomes, several waves of projects have started up and should deliver interesting insights in the near future. A selection of these projects is provided below. Updates on these and future projects are available online:

- http://cordis.europa.eu/fp7/projects_en.html (Theme: FP7-KBBE)

ASFRISK	Evaluating and controlling the risk of African swine fever in the EU
BIAMFOOD	Controlling biogenic amines in traditional food fermentations in regional Europe
COLORSPORE	New sources of natural, gastric stable food additives, colourants and novel functional foods
CONFFIDENCE	Contaminants in food and feed: inexpensive detection for control of exposure
DISCONTOOLS	Development of the most effective tools to control infectious diseases in animals
EAWP	European animal welfare platform: adding welfare quality to food
EMIDA	Coordination of European research on emerging and major infectious diseases of livestock
FACET	Flavours, additives and food contact material exposure task
FLABEL	Food labelling to advance better education for life
GMSAFOOD	Biomarkers for post-market monitoring of short- and long-term effects of genetically modified organisms on animal and human health
KNOWLEDGE2INNOVATION	Promoting the exploitation of scientific knowledge through academia-industry cooperation in the Knowledge-Based Bio-Economy in Europe and beyond
MACROSYS	Macrophage systems biology applied to disease control
NAFISPACK	Natural antimicrobials for innovative and safe packaging
NANODETECT	Development of nanosensors for the detection of quality parameters along the food chain
SYMBIOSIS-EU	Scientific synergism of nano-bio-info-cogni science for an integrated system to monitor meat quality and safety during production, storage and distribution in the EU
TB-STEP	Strategies for the eradication of bovine tuberculosis
VITAL	Integrated monitoring and control of food-borne viruses in European food supply chains

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