Food safety

Genome sequencing for food analysis

ALSO
- Tracking food pathogens
- Next generation sequencing
- Veterinary residues
- Meat fraud
- Crisis management
- Food Safety Modernization Act
- Allergy awareness
- Personalised nutrition
- Fuel cells
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- Fast multiplex real-time PCR
- Based on ISO TS 15216
- Differentiates between GI and GII
- Process control included
- Matrices validated include shellfish, berries, leafy greens, ground beef, etc.
Decline in UK campylobacter cases

New figures from UK surveillance bodies show a 17% reduction in the number of laboratory reports of human cases of campylobacter in 2016[1]. The Food Standards Agency (FSA) estimates that there are 100,000 fewer human cases of campylobacter overall. Achieving this reduction is estimated to lead to a direct saving to the economy of over £13m in terms of fewer days off work and NHS costs.

Levels of campylobacter in chicken continue to decline, as demonstrated in the first set of results from the FSA’s third year survey of campylobacter on fresh shop-bought whole chickens, published recently. The results for the first five months of the third retail survey, from August to December 2016, show: Overall, 7% of chickens tested positive for campylobacter within the highest band of contamination.

Among the nine retailers with the highest market share, 5% of chickens tested positive for campylobacter within the highest band of contamination.

The results demonstrate a decrease in the number of birds with the highest levels of campylobacter contamination compared to the same months in 2015 and 2014. The new data show 7% of chickens tested positive for campylobacter within the highest band of contamination, down from 12% for the same period in 2015 and 20% in 2014. Research has shown that reducing the proportion of campylobacter-positive birds within this category will have the biggest positive impact on public health.

The percentage of chickens from the nine retailers with the highest market share (representing over 80% of chicken sales) that tested positive for campylobacter varied within the same months in 2015 and 2014. Progress has been made by the larger processing plants, supplying the major retailers, towards reaching the target that was agreed with industry to reduce levels of the most heavily contaminated birds at slaughter to net more than 99.9%. However, overall the industry has not yet met this target. This is partly because the smaller independent plants (which tend to supply smaller retailers) have yet to make similar improvements.

The percentage of chickens that tested positive for the presence of campylobacter at any level is 56%, down from 66% in 2015 and 78% in 2014. This includes samples with very low levels of campylobacter, which would be unlikely to cause illness.

The FSA is changing the way it monitors levels of campylobacter on chickens at slaughterhouse level by ending the monitoring programme in its current form.

This will not impact on the retail survey, which will continue to be reported and will be the method by which the large processors and retailers will be measured. In order to focus on the processes that are not making significant improvements (generally the small-medium sized poultry plants), the FSA is developing plans to target specific sites with FSA inspections.

The continuing decreases in the number of campylobacter infections increased; this was likely to be due to newly available rapid tests that make infections easier to diagnose, rather than a true increase in illness.

Food evolution – the movie

As part of the programme for the Institute of Food Technologists (IFT) 75-year anniversary, IFT commissioned and funded Food Evolution, a documentary which addresses the use of sound science in our global food system, looking specifically at the polarised debate over genetically-modified foods.

Directed by Academy Award-nominated Scott Hamilton Kennedy and narrated by Neil deGrasse Tyson, Food Evolution shows how easily fear and misinformation can overwhelm objective, evidence-based analysis.

The film has so far been shown at private film screenings, with the first UK screening, organised by IFT’s British Section, taking place in May 2017 at the SCI in London.

The filmmakers are pursuing a variety of possible distribution channels in an effort to bring the film to as many viewers as possible.
Food donation service

TAAP, a supplier of mobile software applications for tablets and smartphones, has developed a Feed Surplus Application to assist with the donation of surplus feed in the retail sector to charities\(^1\). It is currently being deployed by Tesco in its UK stores and integrates with systems from Tesco partners – FoodCloud and FanShare. The Food Donation Service is a plug-and-play solution that integrates with a retailer’s stock, price and waste services to digitally track and trace what is being donated. Retailers check stock levels and notify charities of the times of products that will be available using the FoodCloud app and, if accepted, charities/logistics partners collect the chosen products. On collection, the products with short shelf lives are barcode scanned using the Food Donation Service app, which then creates a virtual ‘shopping basket’ for charities to accept.

The app records a complete audit trail of which items have been donated and to whom including weight, quantity, price etc. This data is passed back to FoodCloud, and Tesco can mark the product as ‘waste’. FanShare runs the platform via FoodCloud by setting up the charities and co-ordinating associated activity. The app allows retailers to monitor the number of meals donated to help them achieve targets for food waste minimisation and to comply with corporate and social responsibility obligations. The system contains a training mode so that new staff can be trained on a test account. Managers receive notifications to advise when donations should have occurred.

TAAP has designed the Food Donation Service app to work with many handheld tablet and phone devices, including older PDAs, which are still popular in the retail environment. The Microsoft Azure cloud platform is recommended for hosting due to its reliability, scalability and flexibility. The system is agile and allows for changes to be made based on the retailer’s operational requirements and rules. The Food Donation Service is currently live in over 1,300 stores across the UK and ROI and has already saved the equivalent of 5.1m meals from going to waste. Interested retailers should contact TAAP regarding how the system can be used by their organisation to manage food surplus more efficiently.

Campden BRI
Food research in South Korea

Campden BRI has been awarded a contract (€305k) for a joint, three-year food research programme between South Korea and the UK’s National Food Cluster (FOODPOLIS) and Dongguk University. The contract, funded by the South Korean government, aims to enhance food safety, quality and product innovation.

Campden BRI will be working in three key areas: advanced analytical methods for non-targeted chemical screening, analytical methods for difficult to measure components and the commercial exploitation of insects as a source of high-quality proteins.

In support of this new initiative, Campden BRI has also opened an office within FOODPOLIS to encourage international collaboration among food manufacturers and researchers in the North East Asia region.

Industry survey

Campden BRI has carried out an industry survey to better understand industry’s methods to innovation\(^2\). The innovation survey received 126 responses from a wide range of sectors, including ambient groceries, baked products, beers, wines and spirits, prepared convenience foods and retailers. The responses represent a cross section of industry from multinational (39%) and large companies (11%) to medium-sized companies (25%), small companies (17%) and start-ups (<1%). The key findings are:

- Most companies plan to focus innovation on range extension (63%) and developing entirely new products (62%) over the next two years. Other common drivers of innovation were targeting new markets (39%) and start-up (1%)

Food research in South Korea: 2017

Campden BRI and Beef & Lamb Ireland

We are pleased to announce that Beef & Lamb Ireland, through its award-winningapplied research partnership with Campden BRI, has been awardedcatapult funding to support three research priorities. The projects will be delivered in collaboration with the University of Teesside and the University of East Anglia and are expected to generate significant benefits for the Irish beef sector.

1. The first project, entitled ‘Determining the impact of post-mortem handling conditions on beef quality’, aims to explore the effects of different post-mortem handling conditions on beef quality. This research will provide crucial information for meat processing and retailing businesses to optimise beef quality and maximise consumer satisfaction.

2. The second project, entitled ‘Developing a comprehensive approach to addressing food safety concerns in the Irish beef sector’, aims to develop a comprehensive approach to addressing food safety concerns in the Irish beef sector. This research will provide a framework for addressing food safety concerns and improving public confidence in Irish beef.

3. The third project, entitled ‘Enhancing the sensory attributes of Irish beef products’, aims to enhance the sensory attributes of Irish beef products. This research will provide important information for meat processing and retailing businesses to develop and market innovative beef products.

For a comprehensive list of planned Food Science and Technology meetings visit:

\(\text{www.ifstjournal.org/events}\)

References are available online at:

\(\text{www.ifstjournal.org/news}\)
The IFST Spring Conference 2017

IFST NEWS

The IFST Spring Conference ‘Your Future Role in Food: Embracing Advances in Technology’ brought together some of the finest minds involved in new technologies to talk to a diverse and engaged audience at Kings College on 7 April. Opened by the newly appointed IFST President David Gregory and chaired by Professor Ian Noble (Mondelez), the event highlighted some of the global challenges that technology might help us address.

The food system cuts across many of the UN’s sustainable development goals, including issues of water use, waste, the energy required to produce food and the significant public health challenges we are facing today. The speed of technological development opens opportunities to tackle some of the most pressing issues and will transform the way we work and live.

David Crean (VP R&D Mars), the keynote speaker, started the formal presentations by outlining Mars’ project on ‘sequencing the supply chain’, which is building a database using genomic information in the food chain to understand microbial communities, to aid in identifying hazards and deviations and to improve traceability. Starting with one supply chain the intent is to build a tool that can be relied out to all products and create an evolution of HACCP.

The conference was then treated to a talk at the heart of some of the new technologies being developed in agriculture and food manufacturing.

Dave Ross from the Agri-EPI centre introduced us to exciting technologies being considered in the agri-food sector, for example the use of robotics and sensors in animal production, autonomous harvesting/processing and drone sensing for crops. Matt Rayment from the Manufacturing Technology Centre demonstrated a personalised drink bottle that had been designed and 3D polymer printed in less than a day. He discussed how applications from aerospace had been applied in food manufacturing and the use of a simulated food factory to run ‘what-if’ scenarios and improve operational efficiency. Fraser McIvor from Kantar informed us of some key trends in retail and food service that will drive the adoption of new technologies: the ‘squeezed centre’ range of products with growth in value and premium, the reduction in brand supremacy, the growth of Out of Home sales, the blurring of categories and trends towards ‘happier, healthier, more convenient’.

Ian Campbell from Innovate UK then shared examples of successful funding outcomes and called for more applications for funding from the UK Food industry. This was followed by a Q&A session with the speakers. The audience discussed the challenges of communicating the benefits of new technologies and the implications of the increase in the use of robotics. Although some jobs will be replaced, new jobs will be created by new technologies.

The afternoon was split into two sessions, one focusing on consumer technologies, the other on manufacturing and control. In the consumer stream, Larry Wilson from TellSpec talked about its new handheld consumer NIR spectroscopy device and how the company is developing detection capabilities for a range of food quality and safety parameters. This was followed by Professor John Mathers, who communicated results showing that personalised interventions in nutrition healthcare delivered better results than ‘one-size-fits-all’ approaches, regardless of whether personalisation was based on phenotypic or genotypic information.

Meanwhile in the manufacturing stream, Dr Vincenzo di Bari, EPI centre introduced us to the EPSRC Centre for Innovative Manufacturing (CIM) in Food and talked about the role of process, product and ingredient design in food manufacturing. His presentation was followed by Dr Roy Betts from Campden BRI who stressed that as test methods in food microbiology are becoming easier to develop, it is critical we use a method that asks the question we need to answer to get the knowledge we need.

Back in plenary, Geoff McBride showcased some of the facilities and technologies that are available for the food industry via funding from a new STFC (Science and Technology Facilities Council) food network (http://www.stfc.ac.uk/funding/) and Ian Noble wrapped up the conference by noting the many opportunities to do good science in the food industry, reminding us of the need to leverage networks to access those opportunities. Technologies, such as genomics, simulations, advanced sensing, scanning, robotics and the ability to generate, manipulate and utilise new data sources are increasingly available to help realise our innovation and efficiency aspirations for the future.

Presentations and videos are available for members on the IFST website.

International Journal of Food Science + Technology

Recent highlights on food authenticity

Identifying geographic origin of teas

Aroma and volatile profiles of chrysanthemum flower teas were established for use in quality control and geographical origin identification. The profiles were based on volatile and aroma-active components identified by gas chromatography-mass spectrometry and olfactometry (GC-MS–O) and electronic nose (E-nose). Results showed that 84 volatile components were identified in five chrysanthemum flower teas, including terpenes, alcohols, ketones, aldehydes and esters. The key volatile (aroma-active) components resulting in the tea sample differences were determined. (Lue et al., 2017, doi:10.1111/j.1326)

DNA barcoding for fish species identification

DNA barcoding was used for species identification of 64 Indonesian commercial fishery products. The 155-bp cytochrome C oxidase subunit I (COI) gene fragment marker was successfully amplified and used to identify 86% of the total fish samples at the species level using the BOLD and BLAST public databases.

This study demonstrated that COI barcoding is a promising tool for Indonesian fishery products and confirmed that it could be adopted for regular seafood control as part of the Indonesian integrated food traceability system. (Abdullah and Rehbein, 2017, doi:10.1111/jfts.13278)

Reading it Right on Novel Foods – new food law regulation

On 1 January 2018, Regulation (EC) No. 258/97 on novel foods and novel ingredients will be repealed and replaced with Regulation (EU) No. 2015/2283 on novel foods. Although the incoming Regulation has the same ‘cut off’ date of 15 May 1997 for defining a novel food, it brings some changes to the authorisation process and classification of categories of novel foods.

Expert speakers will meet on 27 September 2017 to discuss the implications of these changes, such as the points expected to be of priority in future reviews of novel foods and the potential effects of Regulation 2015/2283 on certain food categories already present on the market. The event is organised by IFST Food Law Group. For more information and to book your place, please visit: http://www.ifst.org/events/reading-it-right-novel-foods
Honorary Fellowship for Colin Dennis and Michael Walker

Colin Dennis, above left, and Michael Walker, above right, have been awarded Honorary Fellowship Awards. Honorary Fellowship is awarded to Members and Fellows who have made extensive personal contribution to the working and progress of the Institute and to the food science and technology profession.

Colin Dennis’ career in food science spans 47 years. He was appointed as the first mycologist at the UK Government Institute of Food Research (IFR) in Norwich, where he subsequently headed the Mycology and Fruit & Vegetable Storage sections.

He is a member of the European Academy of Allergy & Clinical Immunology and facilitated a Food Allergy & Food Intolerance Knowledge Network for 5 years to 2015. His non-executive director experience includes as a founder board member of the FSA. He commented: ‘IFST is highly regarded for its rigour, independence and professional standards; it is a welcoming and supportive – attributes stemming from its founders and perpetuated by the exemplar culture of its officers, executive team and volunteers.

I am proud to be part of an IFST that is a beacon for food safety and standards, protecting consumers and responsible businesses and fostering learning and development in turbulent times. As I reflect on the pleasure this award gives me, I am conscious of being part of a team, both in the Northern Ireland branch and the Scientific Committee, and I am grateful for the good friends, wise mentors, encouraging colleagues and intriguing problems of my food career and especially for the support and active help of my wife and business partner Maria. I am immensely encouraged by the talent and enthusiasm of the upcoming generation of IFST committee volunteers in Northern Ireland and the skills, well-articulated by students in our competitions and Launchpad activities. IFST has a bright future, I look forward to being a continuing part of that, thank you, IFST, for this award and I trust I can live up to the honour accorded me.’

Michael Walker is a Chartered Chemist and Fellow of both IFST and RSC. He holds the MChemA, the statutory qualification to act as a Public Analyst in the UK. He was the resident public analyst for the 26 local authorities of Northern Ireland from 1986 to 2016. His current portfolio includes Referee Analyst in the Laboratory of the Government Chemist, LGC, where he also manages research on allergen measurement, Chair of the FSA NI Strategic Committee on Food Surveillance, a thriving chemico-legal practice, member of the IFST Scientific Committee and a Training Officer for the Association of Public Analysts.

Michael was a subject matter expert to the UK DH/Defra Elliott Review in the aftermath of the horse meat scandal and continues to advise government on aspects of the Review. Michael formed his own consultancy in 2004 following extensive experience as a partner in a private laboratory practice, Public Analyst, non-executive Director and in forensic Science Northern Ireland.

Sustainable Food Systems Framework

There is a clear and urgent need for science and applied technologies to help deliver sustainable food systems, which provide food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised (IPCC, High Level Panel of Experts on food security and nutrition). IFST as the ‘Voice of the Food Professionals’ is placed to bring focus to important aspects of developing sustainable food systems.

To direct our efforts in a wide topic area, we commissioned a workshop to work with us to develop a Sustainable Food Systems Framework. The aim of this report is to focus activity on practical elements where IFST can make a real impact that is most relevant to our members and also benefit wider society. The report outlines key themes that provide a framework for IFST to develop guidance, new knowledge, policy and other initiatives to support the vision of sustainable food systems, while keeping a focus on food, technology and evidence.

Recommendations for broad activity areas are made under each of these themes:

1 Resource risks and protection: the food system is dependent on the natural environment and at the same time is causing significant environmental impacts. IFST can contribute to UK and global policy to increase food system resilience through:

- Developing guidance for food industry on mitigating the impact of emerging global environmental risks.
- Supporting research to identify how food science and technology could help the industry adapt to the impacts of climate change.
- Identifying how a broader set of environmental and social risks can be integrated into food business and supply chain risk management.
- Being a vocal advocate to increase efforts to address climate change mitigation and adaptation in the food sector.

2 Healthy sustainable diets: there is a need to deliver good human and environmental health outcomes from the food system at the same time. Partnering with appropriate technical colleagues, IFST can:

- Help develop and disseminate best practice guidance on how to incorporate sustainability into the assessment of new processes and products.
- Designing in sustainability to NPD or R&D processes.
- Contribute to development of solutions to the global challenge of food and nutritional waste through the application of science and technology.

3 Circular economy and sustainable manufacturing – the current economic model of ‘take-produce-consume-discard’ is unsustainable. IFST can:

- Address food safety and regulatory perspective challenges to support the increased use of wastes and by-products as inputs to other processes and sectors.
- Support and promote initiatives to increase resource efficiency through reducing energy, waste and water in the food industry.
- Facilitate the creation of new practical energy standards for SMEs.
- Support optimisation of the usability of foods through the improvement of product date/storage/usage labelling information.

A New Sustainable systems and ingredients – there are opportunities for developing new farming and manufacturing technologies to deliver sustainable nutrition. IFST can:

- Contribute to the technical, legal and consumer-acceptability challenges of future protein technologies.
- Promote or support research in the food system to improve and increase use of data-enabled technology and artificial intelligence.

5 Decent work and equitable trade – the livelihoods and working conditions of the 1+ billion people who work in the food system need to be improved. IFST can:

- Address food safety risks and disadvantages of a move towards more automation in the agri-food supply chain.
- Transform food traceability and trust – new software and data can help drive improvements in food system sustainability and strengthen consumer trust. IFST can:

- Increase industry knowledge of emerging traceability and transparency technologies in supply chains.
- Support development and uptake of innovative approaches to assuring the sustainability of supply chain actors.

IFST with its member working group will now use this framework and the recommendations to develop more specific activities, which will need to be addressed in conjunction with many organisations and individuals who are affected by or are already working in these areas.

The report identifies some of those key stakeholders as potential partners and IFST is open to discussion and collaboration with these other interested parties. For more information or to initiate that discussion please contact John Bassett, Policy and Development Director, IFST at j.bassett@ifst.org.
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MIFST, Technical
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Anita Kinsey CSci, Technical Manager – Pret A Manger

Registered Food Safety Managers
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Tracking down the genes of foodborne pathogens

**Kaarin Goodburn**, of the Chilled Food Association, and **Edward Haynes**, of Fera, look at the development of genome sequencing technologies and their potential uses in tracking food contamination microorganisms. They consider technical, practical and policy issues to be resolved from a food perspective.

**Introduction**
Since the discovery of the structure of DNA and the genetic code, the importance of understanding genetic variability and diversity in relation to the biological world has become clear. The ease and speed of identification of microorganisms has, in the last three decades, undergone major development – from plating out on to selective media, Gram staining, biochemical reactions, sero- and phage typing, amplification-based techniques (e.g. PCR, Amplified Fragment Length Polymorphism, Multiple Locus Variable Number Tandem Repeat Analysis), restriction enzyme-based techniques (e.g. ribotyping, Pulsed Field Gel Electrophoresis) and, most recently, whole genome sequencing (WGS). WGS is just one of the techniques covered by the umbrella term Next Generation Sequencing (NGS). In just over 20 years since the first sequencing of a bacterium’s genome, technology has advanced such that a microorganism can now be sequenced in a day or less using WGS.

Internationally, researchers, governments and industry are now using WGS to track pathogens’ movements in greater detail than was previously possible. The result has been the creation of libraries of genome data, such as that produced by the GenomeTrakr Network, which receives more than 1000 genomes a month from laboratories in Argentina, Australia, Austria, Canada, Denmark, Germany, Italy, Ireland, the UK and the USA.

WGS can help to:
- rapidly determine potential sources of single cases of illness, outbreaks and contamination events
- determine microorganisms’ characteristics including resistance to antibiotics
- reveal the epidemiology of previously unlinked cases of infection.

**Technologies**
A range of molecular tools has been developed to distinguish between different strains of pathogenic microorganisms. The purpose of this is to be able to differentiate between unrelated infection or contamination events and link together those that are epidemiologically connected. Many of these tools are applicable to bacterial pathogens and can distinguish between different lineages with varying degrees of discrimination. Some of these techniques are outlined below:

**Matrix Assisted Laser Desorption/ Ionisation-Time of Flight**
- **MALDI-TOF**
- Matrix Assisted Laser Desorption/ Ionisation-Time of Flight is a rapid, proteomics-based approach to identify bacteria to species level cheaply. MALDI-TOF compares the protein profile obtained from a bacterial culture to a library of known patterns to accurately and rapidly identify the species. The approach currently struggles to identify bacteria to subspecies or below, but advances in that direction are being made.

**Serotyping**
The differentiation of bacterial subtypes based on the presence of different cell surface antigens. This approach is particularly well established for some bacteria, such as *Escherichia coli* or *Salmonella enterica*. Indeed, there are over 2,500 known serotypes of *Salmonella*. However, in the UK, approximately half of *Salmonella* infections are caused by either *Salmonella Enteritidis* or *Salmonella Typhimurium*. Therefore, if a clinical isolate belongs to one of these serotypes, it gives limited additional information about its potential source.

**MLST**
- **Multi Locus Sequence Typing** - A DNA-based approach, which uses DNA sequences of around seven conserved genes within a bacterial species to identify subtypes. This approach is discriminatory, portable (methodologies and data are easily transferred between laboratories) and gives information about bacterial population structure, which can be useful for understanding outbreaks. Importantly this approach gives a nomenclature which makes independent studies highly comparable.

**PFGE**
- **Pulsed Field Gel Electrophoresis (PFGE)**
- Previously thought of as the gold standard for pathogen subtyping, PFGE involves enzymatic digestion of DNA followed by gel electrophoresis with a voltage which periodically changes direction. This allows very fine level discrimination between strains. However, the technique can be cumbersome and there may be an element of subjectivity about
Genetics timeline

1859 Charles Darwin publishes On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life.

1864 Gregor Mendel discovers the basic principles of genetics. This is formally acknowledged in 1900.

1869 Friedrich Miescher first identified what he called ‘nuclein’ in the nuclei of human white blood cells – deoxyribonucleic acid (DNA).

1882 Walther Flemming discovers mitosis and chromosomes.

1905 Wilhem Johannsen coins the term ‘genetics’.

1909 Erwin Chargaff discovers that DNA composition is species specific.

1953 Discovery of DNA double helix structure by James Watson, Francis Crick, Rosalind Franklin and Maurice Wilkins.

1961 Marshall Nirenberg and others crack the genetic code, linking the DNA sequence to protein synthesis.

1977 Fred Sanger and Walter Gilbert independently develop automated sequencing – Sanger Sequencing.

1978 First genome is sequenced using Sanger Sequencing – 5,386 bases – Escherichia coli bacteriophage 4917A.

1983 Polymerase chain reaction (PCR) developed by Kary Mullis for amplifying DNA.

1986 First automated DNA sequencer marketed.

1990 The Human Genome Project begins, aiming to sequence the entire human genome.

1995 First bacterial genome sequencing barcodes of pathogens isolated from food or environmental samples. This relies on a well populated database against which to compare samples. Some countries have made difficult strides towards this than others. WGS data can be used to:

- Help produce geographic origins of pathogenic isolates, potentially aiding significantly in outbreak delineation.
- Establish links to wider, internationally cooperative efforts.
- Investigate historic events and potential directions of transmission.
- Potentially reveal new pathogen.
- Help predict the geographic origins of pathogenic isolates, especially in the context of emerging or unknown pathogens.
- Increase outbreak delineation.
- Potentially aid in successful vaccine and drug development.
- Determine drug resistance patterns.

1996 The ability to routinely perform WGS on bacteria has come about as a consequence of increased outbreaks and therefore provide a greater appreciation of events.

1997 Establish trends or shifts in successful variants, e.g. any increase in antibiotic antibiotic resistant strains.

1998 Identify shifts in and uptake of genes, e.g. stx1, stx2 and eae in E. coli.

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2003 The basis of using similarities in sequence data is evident in recent reports of the presence of unusual contaminants, such as human or rat DNA in processed foods.

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2018 Identify shifts in and uptake of genes, e.g. stx1, stx2 and eae in E. coli.

2019 Potentially reveal new pathogens.

2020 The basis of using similarities in sequence data is evident in recent reports of the presence of unusual contaminants, such as human or rat DNA in processed foods.

2021 Difficulties in application. In particular, it should be noted that the presence of a gene does not necessarily indicate presence of a live organism. An isolate should lead to erroneous conclusions. The impacts of poor quality or over ambitious claims made on the basis of WGS data.

2022 The basis of using similarities in sequence data is evident in recent reports of the presence of unusual contaminants, such as human or rat DNA in processed foods.

2023 Genetic variations across pathogens isolated from food or environmental samples. This relies on a well populated database against which to compare samples. Some countries have made difficult strides towards this than others. WGS data can be used to:

- Help produce geographic origins of pathogenic isolates, potentially aiding significantly in outbreak delineation.
- Establish links to wider, internationally cooperative efforts.
- Investigate historic events and potential directions of transmission.
- Potentially reveal new pathogen.
- Help predict the geographic origins of pathogenic isolates, especially in the context of emerging or unknown pathogens.
- Increase outbreak delineation.
- Potentially aid in successful vaccine and drug development.
- Determine drug resistance patterns.
The benefits of this collaborative approach were seen in a pilot study between Fera Science and a food manufacturer interested in exploring the origin of Listeria spp. detected in its facility. Combining the microbiological sampling and expertise of the manufacturer’s contract lab with Fera’s WGS capabilities allowed the sequencing and interpretation of genomes from a number of different Listeria spp. This information enabled researchers to suggest potential sources of contamination. For example, the same type of L. ivanovi was detected in a drain and on finished products; this could indicate transmission in one or other direction or contamination from a common source. Greater temporal sampling would allow an investigation into whether the drain was persistently contaminated, with the same type of L. ivanovi. In another example, a finished product contained the same type of L. innocua as a raw ingredient, which was not used to make the product. This indicates that there had been some transmission event from the raw ingredient area of the plant to the high care environment, which is useful information to aid further investigations.

Current technical issues regarding WGS

Issues include:
- Individual DNA sequences generated on NGS platforms are usually not 100% accurate. Improvements in accuracy could only be achieved either by technologies, such as using high fidelity polymerases or PCR-free library preparation. Accurate WGS relies on the generation of a consensus sequence by sequencing the same region multiple times.
- Currently RNA sequencing is laborious and expensive. The generation of complementary DNA from RNA transcripts, which can introduce biases. In the near future however, some technologies (e.g. Nanopore) will be able to directly sequence RNA molecules. This will have a number of implications as the presence of RNA shows which genes are being transcribed, indicating what an organism is doing and implying that it is, or recently was, alive (due to RNA’s generally more rapid degradation than DNA).
- Method and laboratory certification is not well developed. There is some initial accreditation for some small parts of the workflows and some proficiency testing occurs either in-house (e.g. FDA) or organised by consortia (e.g. Global Microbial Identification (GMI)). Some initial guidelines have been developed by some organisations (e.g. CDC). GMI is also working on standards.
- Risk of sample contamination. Some NGS techniques (e.g. metabarcoding, RNAseq) are at greater risk of contamination through their reliance on either PCR or their identification of pathogens from low numbers of sequences. In a laboratory environment, the risk of contamination can be reduced by physical separation of stages (e.g. PCR setup and PCR product clean-up), physical protection of samples from user contamination (with appropriate personal protective equipment), regular disinfection and use of appropriate controls. When genome sequencing from pure bacterial cultures, the target DNA will be in massive excess and when mapping back to a reference the coverage can be a guide to identity. Plasmids or conserved regions might have higher than average coverage, but accidental contaminations will likely have relatively low coverage in normal circumstances.
- Risk from external contaminations when using portable sequencers. It would be difficult to sequence microbial genomes without the use of culture-based techniques, as background genetic material will be in excess, unless some form of enrichment is used or sampling matrices with low amounts of host DNA (e.g. urine). Current protocols use sequencers will perform when sampling e.g. irrigation water, is not currently clear.
- Assembling a complete and fully accurate genome sequence from short read data is not always possible. Some areas of the genome are highly repetitive and isolates may have sequence that have been inserted or deleted, both of which can complicate assembly and subsequent alignment (use of a reference genome to piece a genome back together following sequencing of DNA fragments). Long read technologies and a range of assembly software can assist resolving these problems, as can complementary techniques, such as mate-pair sequencing. It is currently challenging to rapidly compute and interpret the relevant information from large data sets.

Taken together it is apparent that making direct linkage between clinical, food or environmental samples is not straightforward. Dr Peter Gerner-Smidt of CDC stated at the September 2016 ISPH Whole-Genome Sequencing for Food Safety Symposium that: “A WGS match between a food isolate and a clinical isolate does NOT mean the food caused the patient’s illness. They likely share...” and that “...finding a match somewhere in the food production chain...” Epidemiological and traceback information remains critical.

Practical application of WGS

The current technical issues to be resolved in WGS are compounded by additional practical issues when it is used in food safety applications:
- How many SNPs comprise the genome?
- What is a valid case definition and how do agencies interpret and apply it?
- What is an outbreak?
- What are the implications of WGS for identifying antibiotic resistance genes?
- How will any emerging food safety concerns be communicated and by whom to whom?
- How will partners and stakeholders agree in advance on appropriate use of data? Will this need to be done at international level? What would interpretation criteria be?
- Is isolate ownership a problem? How can national, regional and international criteria be?
- How should methods, metadata and attribution be standardised? Harmonised internationally?
- What are the requirements for IT and bioinformatics infrastructure?
- How should data integration, sharing and knowledge transfer be managed?

Providing these issues, validated interpretation criteria must be established for the use of WGS and the weight of all evidence should be assessed, i.e. WGS in parallel to the primary tests and epidemiological evidence, and carefully interpreted on a case-by-case basis. One problem with epidemiological investigation of foodborne outbreaks and incidents is that people may be asked to complete historic food consumption questionnaires covering periods of several weeks, where recall may be incomplete or inaccurate, potentially highlighting incorrect food vehicles.

Conclusions

WGS is a major advance in gene sequencing technology, presenting many opportunities for gaining greater understanding of disease identity, genetic nature and presence of microorganisms. However, the technology is still being developed and remains immature, requiring the development of WGS criteria be?... How will it be applied?... What conclusions can be drawn? The use of the data require careful consideration by all using WGS, particularly governments and their agencies, laboratories and food businesses.

References and available article online at: www.fstjournal.org/features/31-2-genome-sequencing

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Enhancing food safety with Next Generation Sequencing

Mahni Ghorashi of Clear Labs in California, USA, describes a new food analytics platform that uses next generation sequencing to analyse the molecular makeup of food samples.

The impact of food product recalls

On May 31, 2016 Golden Valley-based General Mills voluntarily recalled 10 million pounds of Gold Medal flour, Wondra flour and Signature Kitchens flour after a potential E. coli outbreak in its products.[2] The company subsequently expanded the recall dates, first in June and again in July, adding another 20 million pounds to the recall list. Fortunately, the outbreak did not result in any fatalities, but it is expected to have cost the brand millions of dollars in lost sales and brand reputation.

Food recalls cost an average of $15m per incident and cause significant harm to brands’ reputation and credibility. They can also cause significant harm to individuals. In the United States alone, foodborne illnesses make 48 million people sick and are responsible for 3000 fatalities every year.[3]

As Bill Marler, a Seattle lawyer specialising in food poisoning lawsuits against food companies, remarks in response to the General Mills E. coli outbreak, ‘We are likely to continue to see ongoing recalls of other products. It looks like the wheels on the bus are coming off, but it’s actually a positive thing. I see recalls as a sign the system is operating like it should. Recalls, in the long run, are a positive for food safety.’

Despite the fact that the majority of brands have maintained a strict adherence to food safety protocols, the food safety climate is on the brink of a transparency crisis, with the negative publicity generated by a rising number of high-profile recalls continues to reinforce consumer skepticism regarding the food industry’s ability to ensure safety.

Food analytics platform

Clear Labs was founded in 2014 by a group of software engineers and genomic scientists to set worldwide standards for food integrity. Its aim is to help customers mitigate risk through data-driven intelligence.

It has developed a pioneering new food analytics platform, Clear View, which uses Next Generation Sequencing (NGS) technologies to analyse the composition of DNA in food samples, allowing food manufacturers and retailers to improve the transparency of their supplier network and build stronger food safety programmes.

The US Safe and Accurate Food Labeling Act of 2015[4] requires the labelling of genetically modified foods, known as GMOs (genetically modified organisms). Clear Labs offers a comprehensive GMO test with coverage of all known GMOs, allowing manufacturers to label products as GMO-free.

The NGS-based food tests and software analytics have potential to significantly improve the scalability and accessibility of food safety and quality measures, by comparison with conventional technologies, such as PCR and Elisa-based testing, which have inherent limitations as highlighted by several high-profile outbreaks and recalls in 2016. Compared to 2015, recalls surged by 22%.[5]

The food analytics platform can complement food manufacturers’ or retailers’ existing food safety programmes. Laboratories have the option to subcontract NGS testing to Clear Labs, or use the technology to conduct their own tests (Figure 1).

Analytical programmes can be up and running with NGS in a matter of weeks. Clear Labs has developed APIs (Application Programming Interfaces) that allow customers to work with food data across various sources and tools so as to not disturb a brand’s existing safety management processes.

Database

In order to provide analytic insights, Clear Labs is building a massive molecular reference database. This would not have been possible a decade before the introduction of NGS in 2005. NGS technologies, developed at Illumina, Roche, Life Technologies, and a number of other firms, have dramatically reduced the time and cost of DNA and RNA sequencing, revolutionising both the discovery and application of genomics and molecular biology.

The technology has matured remarkably quickly. Late last year researchers at The University of Toronto launched a massive project to sequence the genomes of 10,000 people per year[6]. This is truly astounding, considering that it took 13 years and $3b to sequence the first human genome and that as recently as 2012 there were only 69 whole human genomes that had ever been sequenced.

For genomes are far less complex than human genomes, and since establishing Clear Labs in 2012, the company has continued to build its reference database for food. The world’s largest, it currently spans over 2 million entries and tens of thousands of food products and ingredients.

This database powers a unified, sample-to-answer, analytics platform that connects comprehensive testing results with product metadata (type, origin, ingredients, nutrition data and label claims).

The analytics platform can be leveraged to access the food database, a library of algorithms and customisable reporting tools.

Why NGS?

NGS is poised to replace PCR and Elisa as the standard in food safety testing. The technology is ready for food industry applications including food safety, food authenticity, GMO, and food microbiome testing as well as Whole Genome Sequencing (WGS).

The primary limitation of PCR is that it is targeted, so it is necessary to know what you are looking for in order to test for it. It is also conducted one target at a time, so a separate run is needed for each target chosen. This is costly and difficult to scale up.

By contrast, NGS-based testing is universal. A single test exposes all potential threats, both expected and unexpected, because instead of testing for one gene at a time, millions of reads are sequenced at once. A single NGS test can reveal the presence and concentration of bacteria, fungi or allergens as well as the precise composition of ingredients in any given sample, helping to guarantee that hazards do not slip through the supply chain.

PCR-based tests have high limits of detection and cannot be used to distinguish between closely related species. NGS-based tests, on the other hand, have low limits of detection; the increased sensitivity of NGS provides more accurate results along with much higher levels of specificity. For example, a study conducted by the American Veterinary Microbiology Institute[7] that analysed the results from 39,500 food proficiency tests conducted between 1999 and 2012 found that routine pathogen testing with NGS detected 100% of target genomes, while PCR or antigen/antibody-based methods detected 98%-99% of target genomes. At scales of hundreds of thousands of tests per year, the reduction in number of false negative rates, each a potential recall, is substantial.

There is a concern that adopting new technologies, especially those which promise increased levels of transparency, will increase exposure to regulation and litigation. On the other hand, no one wants to slip through.

The technology that is to their advantage is that they are disregarding consumer concerns, especially at a time when consumers are most aware of food safety and quality are at an all-time high. Millennials are now the driving generation,[8] and, as consumers, they are more likely than their forbears to research what goes into the products they buy and to buy from brands that demonstrate a commitment to social good.[9]

There are numerous ways to leverage NGS technologies in food safety applications that empower manufacturers without adding substantial risk. While WGS, for example, provides unprecedented levels of transparency, manufacturers who have access to analytics platforms can maintain control of what they voluntarily test for, customise internal reporting and create private, secure libraries for WGS. In contrast, introducing new technologies does not preclude having to make hard decisions that weigh the risk of not being compliant against the risk of product recalls. Brands that have adopted new testing technologies may actually be able to execute on these decisions more quickly and at less cost.

Applications

Among other solutions, NGS and WGS are driving the rapid development of microbial strain tracking technology in the food industry to identify persistent or resident pathogen strains and high-risk environments for pathogen growth.

These technologies are also proactively staying a step ahead of new regulatory protocols. The Food Safety Modernisation Act (FSMA) (see page 36) now gives the FDA power to access records and conduct on-site inspections.
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NGS-powered environmental monitoring has been particularly useful in facilities that produce ready-to-eat (RTE) products, which are exposed to the environment and have no kill-step for pathogens after packaging. Genomics powered environmental monitoring can also verify the effectiveness of routine monitoring programmes and surface insights that inform more effective and more efficient processes. A leading meat and poultry manufacturer, for example, is using Clear Labs to screen plants and houses for resident versus transient pathogens. The company has been able to more accurately identify pathogen strain types and their origin, reduce recall risk through proactive testing, as well as liability through encryption and data matching.

NGS technologies can also help brands dramatically reduce their exposure to food fraud and third-party contamination. Food fraud, which occurs in up to 10% of all food types, precipitates serious public-health risks and costs the global food industry $1.2-1.5tn annually. When an NGS-powered authenticity test reveals unexpected ingredients and contaminants, the platform automatically generates an internal report. The report depicted in Figure 2, alerted a Clear Labs customer to the fact that its supplier had engaged in economically motivated adulteration (EMA). The US FDA (Food and Drug Administration) and FSMA now require food facilities to implement preventative controls to avoid fraud. Deploying traditional PCR-based tests for supplier verification is costly and the results are not reliable since PCR cannot distinguish between closely related species and has high false-positive rates. NGS-powered tests reveal episodes of contamination and adulteration that would be likely to remain undetected. The Clear Labs authenticity test can also be used for undeclared allergen and pathogen identification, which account for more food recalls than any other form of contamination[6].

Figure 3 is a report generated for an existing customer, which reveals both the presence of an undeclared allergen and the absence of listed ingredients. It clearly illustrates the difference between PCR and NGS testing. To detect the presence of an allergen that could easily trigger a recall using PCR-based tests, a brand would have had to specifically test for soy. Rather than wait for an outbreak before conducting a battery of tests to locate the source of an allergen or contaminant, a brand leveraging NGS testing can proactively analyse samples to mitigate risks.

Conclusions

Traditional thinking is that adopting high-transparency technologies might expose food products to liability and increased scrutiny, but food brand recalls are so exorbitant in cost as to manage that increased monitoring and transparency of the supply chain is essential. The perceived value of food-industry goods is determined by consumer demand and while the food industry’s decisions on operational and process innovation have traditionally been based on legal and regulatory counsel, gaining consumer trust by employing technologies, such as NGS, that enhance transparency, will be increasingly important in the future.

Now, more than ever before, it is the food-industry’s scientists and researchers, those charged with applying new technologies to solve real problems, who can best help endow our products with value.

References and article available online at: www.fstjournal.org/features/31-2/food-analytics-platform

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Figure 2: Economically motivated adulteration (EMA) detected in supplier

Figure 3: Presence of undeclared allergen and missing ingredients

H umane care of animals includes administration of veterinary medicines for prophylaxis and treatment of specific diseases and control of parasites. This benefits animal welfare through alleviation of pain and suffering and makes the supply chain, where animals are reared to produce food, more secure. Animal husbandry and aquaculture also use veterinary drugs mainly antibacterial for generalised prophylaxis with increased intensive rearing and for growth promotion. Antimicrobials in food improve feed efficiency resulting in a shorter time to achieve market weight. Prescribed medication to treat human disease, e.g. chloramphenicol eye drops for bacterial conjunctivitis, is generally accepted. But chloramphenicol in our food supply is not – even at concentrations 10 million times lower than the 0.5% in eye drops most of us have used at one time or another. Why is this and what other problems exist with residues of veterinary medicines in food?

Antimicrobial resistance (AMR)

AMR is a global problem, which renders it more difficult, or impossible, to treat an increasing range of infections. Left unchecked, by 2050 AMR could be causing the deaths of 10 million people a year across the world, with $100 trillion in cumulative lost economic output. Addressing AMR demands a holistic approach in human and veterinary medicine and throughout the food supply chain. A recent paper by van Bunnik and Woolhouse[1] challenges the intuitive notion that curtailting the volume of antibiotics consumed by food animals has, as a standalone measure, any impact on the level of AMR in humans.

However, responsible use of antibiotics in agric- and aquaculture is recognised by all stakeholders. In the EU, approval for antibiotic growth promoters has been withdrawn and it is being phased out in the USA. Industry organisations, such as the British Poultry Council, advocate responsible use of antibiotics and antibiotic usage in the poultry industry was reduced by 44% between 2012 and 2015. RUMA [Responsible Use of Medicines in Agriculture] responded to the van Bunnik paper saying the food and farming sector should not divert its current focus on reducing refining and replacing antibiotic use across all sectors[2]. An accessible discussion of AMR is provided in the FSA Chief Scientific Adviser’s 4th Science Report on Antimicrobial resistance in the food supply chain[3].

Allergic reactions and other toxicities

Some of the other risks of veterinary residues in food are discussed below.

Penicillins

It is estimated that 4–11% of the population is allergic to penicillin and its analogues. IgE (Immunoglobulin E) mediated reactions can range from minor skin rash to severe anaphylaxis risking fatalities. The immunogenicity of penicillins is not based on the drug itself, but on protein adducts formed after the β-lactam ring is opened. There are confirmed cases of excess penicillin residues in beef and pork causing anaphylaxis not attributable to sensitisation to the meat.

Chloramphenicol

Foods, such as milk, honey, poultry meat, beef and pork, fish and other seafoods, have been found contaminated with chloramphenicol. The most significant adverse effect from human chloramphenicol medication is aplastic anaemia, an effect for which no dose relationship or threshold has been identified. Although there appear to be no data implicating...
In the 2013 horse meat scandal, Phenylbutazone is a potent contact sensitisers. All of Thyroid cancer is also a potential (mild to severe), haemolytic are common, with skin reactions adverse drug reactions in humans Sulfonamides produced by soil bacteria may be not allow a definitive classification. A small exposure may be necessary Vol 31 Issue 2

Figure 1: Risk assessment process

Risk assessment and management Given the actual and potential harm caused by veterinary residues, systems of risk assessment and risk management are in place in all the major trading blocs. Figure 1 summarises the basic process. Risk assessment also includes premarket approval for new veterinary drugs and rules on something of a ‘near miss’. An anti-inflammatory legitimately used in horses, phenylbutazone was marketed as a medicine for human use in the United States for the treatment of rheumatoid arthritis and gout in 1952. Accounts of serious and sometimes fatal adverse effects are quite abundant in the literature and it was largely withdrawn. Phenylbutazone is now only used in humans for ankylosing spondylitis, a type of arthritis, where other treatments have failed. Although the levels used to treated humans are thousands of times higher than would be expected to be found in horse meat of treated animals, some of the effects of phenylbutazone are reported to be idiosyncratic, not dose-dependent, and in theory might occur at any dose. The assessment of a safe residue level of phenylbutazone in the meat of food producing animals was never completed because key information is not available. Thus, if phenylbutazone is administered, the animal must never enter the food chain. Beta agonists In 1990 there was an outbreak in medicated animal feeds. Risk management includes the imposition of withdrawal periods to ensure residues of the active constituent will not exceed the MRL when the label instructions for the product are followed and that the drug is withdrawn from the animal in good time. Residue monitoring and surveillance for compliance with the applicable MRL also take place (see for example Council Directive 94/22/EC on measures to monitor certain substances and residues in live animals and animal products). Toxicological evaluation of veterinary medicines is carried out by various organisations, such as JECFA, the FDA, and the European Medicines Agency (EMA). EMA has a remit to evaluate both human and veterinary medicines. JECFA is the Joint FAO/WHO Expert Committee on Food Additives, administered jointly by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). Its remit has extended beyond additves into contaminants, naturally occurring toxins and residues of veterinary drugs in food. EFSA comments on questions brought to it by the European Commission, with regular opinions on veterinary residue data and special topics, typical examples being the safety of ractopamine (a β-agonist) in feed, hormone residues in beef and chloramphenicol in food and feed[4]. Zero tolerance and analytical performance For a combination of reasons – serious consequences and/or lack of data – EMA and the Commission took a ‘zero tolerance’ approach to residues in feed of a group of pharmacologically active substances (Table 1). Originally, chlortetracycline was included in the list but in 2014 it was permitted as a vaccine excipient for mammalian food producing species without an MRL but limited to a dose of 20 mg per animal. The prohibited list can found in Table 2 of the Annex to Regulation 37/2010. Directive 96/22/EC of 29 April 1994 also prohibits in food of animal origin thyrostatic substances, various stilbenes, oestradiol 17β and its ester–like derivatives and β-agonists (subject to limited derogations). Prohibition posed some obvious questions on analytical limits of detection and how to deal with potential false positive and false negative findings – type 1 (α) and type 2 (β) errors. An attempt to answer these questions was made by Commission Decision 2002/657/EC implementing the Council Directive 96/22/EC on the performance of analytical methods and the interpretation of results. Detailed criteria are given in...
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for chloramphenicol and 1 µg confidence interval). Both CC_\(\beta\) (a 95% statistical certainty of 1 –

1.00). CC_\(\alpha\) and CC_\(\beta\) are derived from the method validation as multiples of the standard deviation of measured concentrations of blank samples under within-laboratory reproducibility conditions. By definition, CC_\(\alpha\) is a lower concentration and CC_\(\beta\) a higher concentration. But this left open the possibility that different laboratories could certify against a food at different concentrations since CC_\(\alpha\) and CC_\(\beta\) can differ from one lab to another.

Thus in 2003, the European Commission introduced a further criterion – the Minimum Required Performance Limit (MRPL). Alkaloids were the treatment of choice for anaplasmosis and were the mainstay of herbal medicine; aristolochic acid, a major active constituent, is now known to be a carcinogen and a potent nephrotoxin and hepatotoxin.

Nitrofurans are rapidly metabolised in the animal and are widely manufactured and sold worldwide.

Nitrofurans are rapidly metabolised in the animal and residues of the parent molecule can no longer be detected within days, if not hours, of administration. But protein-bound metabolites of four of the five most common veterinary nitrofurans have been identified, which are stable for many weeks. Analytical test methods, mainly developed by Bob McCracken, Glenn Kennedy and colleagues, are therefore based upon measuring these protein-bound metabolites.

For example, by the 1980’s furazolidone was an extremely common feed additive for pig husbandry in Europe. Nitrofurans were the treatment of choice for everything from fly control to parasitic mites in honeybees and aquaculture. Five of the most common veterinary nitrofurans are furazolidone, furaltadone, nifuritol, nitrofurantoin and nitrofurazone. Studies in the 1980’s began to raise concerns about carcinogenicity, mutagenicity of nitrofurans and their metabolites. Nitrofurans are now prohibited for use in food-producing animals in most jurisdictions in the world. However, they are still authorised and popular in human medicine and for the treatment of non-food animals and are widely manufactured and sold worldwide.

Our findings did not confirm the presence of the parent drug, as only the sulfoxide metabolite was detected. We confirmed an exceedance of the MRL in both samples originally analysed and also in two previously unopened cans of the product. One of these contained over 15 times the maximum permitted amount of residue. The consignment was rejected and did not enter the UK.

Conclusions
Veterinary medicines are essential for animal welfare but a stringent control system is necessary to prevent harm to consumers from residues in treated animals, allay consumer fears and prevent incidents that forfeit trust in food safety.

By and large such control systems are in place legislatively. Their practical implementation differs in the main trading blocs although some global harmonisation is evident[10]. It remains to be seen how such harmonisation will interact with global geopolitical changes especially with regard to trade. Sampling and analytical methods for veterinary medicines continue to evolve.

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Pharmacologically active substances or groups

Table 1: Pharmacologically active compounds prohibited in food

Antistreptolysin and preparations thereof: Historically used in herbal medicine; antistreptolysin, a major active constituent, is now known to be a carcinogen and a potent nephrotoxin and hepatotoxin.

Chloramphenicol: Can cause aplastic anaemia in a non-dose-dependent manner, genotoxic and a possible carcinogenic.

Chloropromazine: An alkaloid of plant origin; has been used for treatment and prevention of gout but has a narrow therapeutic index, with no clear-cut distinction between nontoxic, toxic, and lethal doses. Although chloropromazine poisoning is sometimes intentional, orientational toxicity is common and often results in a poor outcome. The genotoxic and teratogenic; no ADI could be established.

Dapsone: A sulfonamide antibiotic used for treatment of leprosy and malarial, originally included in the prohibited list owing to suspected genotoxic carcinogenicity; later studies suggested a non-genotoxic carcinogenicity. Dapsone can occur as an impurity in other sulfonamides from their chemical synthesis with residue findings via this route, has been suggested as a candidate for a reference point for action.

Dimefox: No ADI could be established as a NOAEL could not be identified.

Metronidazole: Antiprotozoal and antibiotic in human medicine but prohibited in food owing to genotoxic carcinogenicity.

Nitrofurans (including furazolidone): Concerns about carcinogenicity and mutagenicity of nitrofurans and their metabolites.

Norfloxacin: Insufficient data to establish a MRL.

References and article available online at: www.fstjournal.org/issue-31-2/veterinary-residues

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The Government Chemist continues to take a very active interest in veterinary medicine analytical and sampling issues to safeguard consumers, industry, regulators and the courts from unwitting measurement errors. For more information see: https://www.gov.uk/government/organisations-government-chemist
Detecting meat fraud

Europe’s horsemeat scandal of 2013 may seem like yesterday’s news but to Dutch horsemeat trader Willy Selten, jailed for two and a half years for his part in the fraud, it probably does not seem such a distant memory. Peter Boddy and David Moss were also convicted in 2015 for activities linked to Horsegate. More recently in October 2016 Alex Ostler-Beech from London, also charged with fraud linked to horsemeat, will be sentenced later this year following containing horsemeat; they will be half years for his part in the fraud.

The method of detection depends on the sequences in DNA. The mass spectrometer will not only have to determine the masses of each peptide, but also their amino acid sequences. This it will do by smashing the peptides into fragments. Each of the many possible fragments arising from a population of peptides traversing the mass spectrometer will be a sub-string of the original peptide. The task then is to turn this vast amount of fragment mass data into information about sequences; this is achieved by database matching. This proteomics route is used to explore a whole suite of proteins within an organism. In the sample, there might be hundreds of proteins and thousands of peptides, more perhaps than even the most expensive mass spectrometer can analyse completely. There is also the additional need for software and database searching involved. This requires a significant level of skill and investment. It is a promising route for achieving non-targeted testing for food adulteration – i.e. looking for the presence of ‘anything unexpected’ in the beef burger off the supermarket shelf – but when seeking horse adulteration in beef the full-blown proteomics approach is overkill.

Targeted testing

When there is prior knowledge of adulteration sources – for instance looking for horse in a sample, not just ‘anything unexpected’ – then it makes sense to use this knowledge in an intelligence-led approach. This is targeted testing. Key proteins associated with the adulterating species, or rather the species-specific peptides arising from those proteins, can be used as species markers. Now the challenge is more focused: look for just the chosen target peptides. Modern mass spectrometers can be programmed to look for entities of specific masses and to ignore everything else, so time and laboratory resources are not wasted tracking peptides and fragments that are not of interest. Another bonus is that there is no database searching involved. If the target peptides are known in advance, then so too are the fragments and the experiment simply amounts to determining the intensities of anticipated fragments in the instrument’s detector.

Key proteins associated with the adulterating species, or rather the species-specific peptides arising from those proteins, can be used as species markers.

The ‘quad’ in triple quad refers to species markers.

Proteomics

One of the most widespread technologies for detecting proteins is mass spectrometry (MS). However, using MS to reliably detect and identify intact proteins is tricky. Instead, the protein of interest is digested with trypsin (enzymatic proteolysis) and the resulting peptide soup is passed through a liquid chromatography (LC) column. The mass spectrometer will typically break in one place, usually the peptide bond between two amino acids, but with enough peptides passing through, all possible fragments will be represented. These fragments are sent through the third and final stage, another mass filter, which scans over the fragments picking out those of predetermined mass. These are forwarded to an ion counter. To complete the picture, it is normal to introduce peptides via an LC column. This whole complicated process, from a peptide entering the first mass filter right through to selected fragments being detected, takes just a few milliseconds.

This type of experiment, using preselected peptide ions and preselected (or ‘preprogrammed’) mass spectrometry or MRM-MS (Figure 1). A key piece of this is the combination of a specific peptide with one of its fragments. This is a transition, written as a pair of numbers – the two charge to mass ratios involved.

The ‘quad’ in triple quad refers to the mass spectrometer. The first stage is a mass filter, which allows only peptide ions of preselected mass (charge to mass ratio) to pass. The second stage smashes these interesting peptides with inert gas atoms. This causes the peptides to break into fragments. Any one peptide will typically break in one place, usually the peptide bond between two amino acids, but with enough peptides passing through, all possible fragments will be represented. These fragments are then the third and final stage, another mass filter, which scans over the fragments picking out those of predetermined mass. These are forwarded to an ion counter. To complete the picture, it is normal to introduce peptides via an LC column. This whole complicated process, from a peptide entering the first mass filter right through to selected fragments being detected, takes just a few milliseconds.

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applied across the electrodes onto the mass selection. There are thousands of triple quads or equivalent instruments in laboratories all around the world. They are used in all kinds of targeted testing, for example the oxime drug residue testing in foods or pesticides in crops.

Meat authenticity

Several research groups have explored MS as a tool in food authenticity, particularly in meat, and several marker peptides have been documented. However, only a handful of research groups across the world have fully embraced MRM-MS for meat authenticity testing. These include Jens Brockmeyer’s group at the University of Stuttgart[1,2], Kate Kemsley’s team at the Quadram Institute Biosciences in Norwich (formerly the Institute of Food Research) and Stefano Sforza and his colleagues at the University of Parma[3].

For detecting, say, horse in a ‘beef’ product using an MRM approach, the starting point is a suite of marker peptides. There are two routes for the relative to populate that list. One is to use a discovery-class machine and a proteomics approach but focus on horse—this is the route taken by the Brockmeyer group. It allows the selection of some highly species-specific marker peptides which, coupled with the Brockmeyer group’s pioneering use of a fragments-of-fragments approach, gives impressive detection abilities. They have been able to detect adulterant pork or horse at around a quarter of 1% level, better than the industry standard, which deems 1% as the threshold for adulteration. They even detected horse in a supermarket canned corned beef product containing horse in beef. This is not absolute quantitation of the type ‘there is x milligrams of horse myoglobin in my beef burger extrard’.

Beef and horse may both contain myoglobin, but since their amino acid sequences differ, they are not strictly the same. Consequently, our group at Norwich describes them as ‘corresponding’. The same is true of some of the peptides arising from the digestion of the two myoglobins. Though some are identical, a few look similar but differ by a variant of an amino acid, so these are termed ‘corresponding peptides’.

The key idea is that the corresponding proteins will behave within their respective organisms in essentially the same way and that their extraction efficiencies will be the same so that the properties of corresponding peptides in the LC and MRM-MS will be comparable. If adulteration then simply calculating the ratios of intensities of matching transitions is a substitute for the relative levels of the two meats in the original sample. This is the so-called CQP (corresponding peptides, corresponding proteins) approach. Proportionality must be maintained throughout for this to work: other detection technologies could be used in a similar way provided they too obey this basic requirement.

Using mixtures of four red meats—pork, lamb, beef and horse in meat products, the Norwich team has successfully demonstrated this type of relative quantitation.

More recently we and other groups have moved beyond raw meats to consider cooked products and so-called complex foods.

Conclusions

It is worth bearing in mind that protein means a lot more than just meat, though meat products are economically important and an obvious technology test bed. Most foods, apart from oils and fats, contain protein and given the incredible sensitivity of modern mass spectrometers, the options for detecting specific protein signatures via peptides, especially in a targeted mode, are very promising. As the Interpol-Europol series of Opson Reports demonstrates, food fraud is a live issue. The list of target foods is constantly growing and the fraudsters are developing means of detecting their presence.

References and article available online at: www.fstjournal.org/features/31-2/detecting-meat-fraud

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More online
Managing food safety withdrawals and recalls

All food businesses are responsible for the safety of the food they produce. Sterling Crew considers how effective food withdrawal/recall management enables food businesses and authorities to build capacity to safeguard food and enhance consumer confidence.

Introduction
Recent food scandals, scares and incidents have reiterated the importance of effective withdrawal/recall management systems. This is illustrated by events relating to foot and mouth disease, dioxin in milk along with the notorious horse meat fraud. There is a legal obligation to inform competent authorities immediately if food that is likely to be harmful to health is placed on the market and that should not be placed on the market or remain on the market. Recall management systems provide a means to allow food operators to withdraw or recall the affected products from the market in a timely manner.

They involved a wide range of food commodities and organisations. Around half of the recalls (117) were related to allergens and roughly a quarter (57) were associated with microbiological and hygiene issues. Physical contamination, such as foreign bodies, accounted for 18% of the recalls. The rest related to other categories, such as unapproved chemicals. The recalls for the first three quarters of 2016 suggest numbers will be as high as in 2015.

Withdrawal/recall planning
A ‘withdrawal’ is defined as a process by which a product is removed from the supply network, except for product that is already in the possession of consumers. A ‘recall’ is the process by which a product is removed from the supply network in which consumers are advised to take appropriate action, such as returning the food or destroying it. The human behavioural element of any withdrawal/recall programme cannot be underestimated. Withdrawal/recalls are by their very nature rare events that many technologists will never experience in their career. Individuals and organisations can be subject to attitudinal ambivalence ‘there are more important urgent matters to deal with first’. Withdrawal/recall plans do not appear important until a crisis to develop a crisis plan. Bad news travels fast with today’s social media platforms and businesses must be prepared to react quickly. They are equally accountable for what they do not do, especially if public health is involved. It is always better to initially overreact and follow a well thought out contingency plan.

It is good practice to conduct a post withdrawal/recall audit to learn lessons and drive continuous improvement. An effective food withdrawal/recall plan (Table 2) consists of a set of documented procedures and support materials that are designed to facilitate the effective and efficient removal of food from the market and provide the correct and timely information to the supply network, consumers and the relevant authorities.

Third party accreditation can give additional confidence in a withdrawal/recall system. Crisis management is a key part of the Global Food Safety Initiative standard, the pre-eminent food safety industry programme. The leading certification standard in the UK is BRC Global Standard for Food Safety. Section 3.9 requires that the food site shall be able to trace all raw material product lots (including packaging) from its suppliers through all stages of processing and dispatch to its customers and vice versa. Also, the site shall test the traceability system across the range of product groups including:

- Microbiological and hygiene issues
- Allergen
- Physical contamination
- Other

Table 1. Number of UK recalls by type and year, 2015-2015

<table>
<thead>
<tr>
<th>Type</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allergen</td>
<td>22</td>
<td>32</td>
<td>63</td>
<td>117</td>
</tr>
<tr>
<td>Microbiological hygiene issues</td>
<td>15</td>
<td>14</td>
<td>28</td>
<td>57</td>
</tr>
<tr>
<td>Physical contamination</td>
<td>11</td>
<td>7</td>
<td>24</td>
<td>42</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>3</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>56</td>
<td>121</td>
<td>233</td>
</tr>
</tbody>
</table>

In a crisis quick action needs to be taken to mitigate the threat. The incident management team needs to follow the prearranged plan, but must be prepared to maneuver according to the circumstances. Facts are assembled to make evidence based decisions. The team should maintain a contemporaneous log of events and decisions. The work needed to be allocated to individuals or teams and resourced, often using external centres of excellence. Protocols to identify and contact internal and external stakeholders should be followed.

It is vital to carry out a ‘post mortem’ after the incident to understand the root cause of the failure and to ensure that lessons learnt are implemented. Individuals and organisations can be subject to optimistic bias ‘it will not happen to our organisation’ or an illusion of control ‘we know what we are doing’. There is also a threat of attitudinal ambivalence ‘there are more important urgent matters to deal with first’. Withdrawal/recall plans do not appear important until a crisis to develop a crisis plan. Bad news travels fast with today’s social media platforms and businesses must be prepared to react quickly. They are equally accountable for what they do not do, especially if public health is involved. It is always better to initially overreact and follow a well thought out contingency plan.

The Chinese character for ‘crisis’ is a combination of two characters for ‘danger’ and ‘opportunity’. Failure can give an organisation a chance to understand their weaknesses and mitigate risk. Protocols to identify and contact internal and external stakeholders should be followed. Organisations should not wait for a crisis to develop a crisis plan. Bad news travels fast with today’s social media platforms and businesses must be prepared to react quickly for continuous improvement.

The International Organisation for Standardisation (ISO) has developed an accredited business continuity management systems standard, ISO 22301: 2012, which is designed to respond quickly and effectively to the threat of sudden disruption to business operations. It specifications the requirements to plan, establish, implement, operate, monitor, review, maintain and continually improve a documented management system to reduce the likelihood of occurrence and to respond and recover from disruptive incidents. A weak Food Safety Management System indicates inadequate risk assessment and planning and leads to poor crisis management.
Food traceability

Food safety incidents have highlighted the value of effective traceability systems. Traceability is a risk management tool, which facilitates food business operators or authorities to withdraw recall food products that have been identified as unsafe. Food traceability is an important component of the modern food supply network and is recognised as an essential tool for ensuring food safety and quality. It is defined as the ability to trace and follow a food, feed, food producing animal or substance intended to be or expected to be incorporated into a food or feed, through all stages of production, processing and distribution (Regulation 178/2002).

Feed and feed operators must be able to trace one step backwards from where the ingredients or feed/food were obtained and one step forwards to where the products were sold. However, it is good practice to ensure that the traceability process extends throughout the total network.

Food supply networks are becoming increasingly complex and globalised, making product traceability ever more challenging. The time taken to identify the problem and locate affected product batches will be critical in the decision making process. A retailer or authority may exercise a precautionary principle if the necessary information is not forthcoming, especially if the potential risk to public health is high. General Food Law requires that food safety records must be available on demand.

Food traceability management systems are resource intensive, which can place a disproportionate burden on small companies. There is also a danger that they can become overly bureaucratic and costly to maintain. But the costs of having an effective system are far outweighed by the potential costs of not having one, especially in terms of the risk to public health.

Food traceability systems have been greatly enhanced and simplified by modern technological developments, including managing traceability data through faster electronic data exchange, which facilitates and integrates more effective supply network information sharing. Table 3 outlines the stages involved in developing an effective food traceability system.

The Rapid Alert System for Food and Feed (RASFF) network is a European warning system that has been in place since 1978. If a food or feed safety risk is identified, it helps to support rapid electronic distribution of information and corrective action. Product identification has been improved using Radio-frequency identification (RFID), barcoding, biochipping and genetic analysis. Consumers place a value on traceability not only because it can enhance food safety but also it is an assurance of a product’s provenance and can enable informed food choice.

Legal requirements

If a potential food hazard has been identified, the resultant food safety risk must be assessed. The food safety risk is a function of the probability of an adverse health effect and its severity, in other words, what is the potential harm and how likely is it to occur? This is a scientific process consisting of four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation. A key part of the assessment could involve engaging with reputable third party centres of excellence, such as the food research associations Campden BRI and Leatherhead, universities, trade bodies, suitably accredited public analysts and laboratories. However, if the food is in control of the operator there is no requirement to notify the authorities.

There are a number of regulations governing food withdrawals/recalls and it is important that individual food businesses are aware that it is their responsibility to ensure compliance to the legislation. Under Regulation (EC) 1882/2004, the Food Standards Agency has the power to enforce a recall if necessary. It is the single point of contact for notifying a recall and communicates the recall information. The Agency produced an official guidance document in 2007, Guidance Notes for Food Business Operators on Food Safety, Traceability, Product Withdrawal and Recall, which provides informal, non-statutory advice to food businesses on compliance with the relevant regulations. However, this guidance lacks detail about good practice in managing a recall and testing and evaluating recall plans. There is also no risk ranking relating to food safety.

Table 3 Developing a food traceability system

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the scope of the traceability system</td>
<td></td>
</tr>
<tr>
<td>Decide on the optimal batch size</td>
<td></td>
</tr>
<tr>
<td>Identify the traceability information needed, including information that must accompany food ingredients used by the food business operator</td>
<td></td>
</tr>
<tr>
<td>Internal process information that is needed to maintain traceability through food processing or preparation where applicable</td>
<td></td>
</tr>
<tr>
<td>Information that must accompany distribution of the food produced by the food business operator</td>
<td></td>
</tr>
<tr>
<td>Establish a system of record keeping and retrieval</td>
<td></td>
</tr>
<tr>
<td>Establish procedures for review and testing of the traceability system</td>
<td></td>
</tr>
<tr>
<td>Document the traceability system</td>
<td></td>
</tr>
<tr>
<td>Develop a challenge approach to the traceability system</td>
<td></td>
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</tbody>
</table>

Guidance Notes only provide advice; the courts alone can decide if an offence has been committed. Regulation IEC 178/2002 on the general principles and requirements of food law aims to protect human health and consumer interest in relation to food. Article 19 of this regulation provides for the withdrawal from the market of foods ‘not in compliance with the food safety requirements’ and requires food businesses to inform the competent authorities, and if necessary the consumer, of the reason for its withdrawal.

Conclusions

Improvement in food crisis management and systems enables food business and authorities to build capacity to safeguard food and enhance consumer confidence. Food businesses must be prepared to challenge their withdrawal/ recall management systems and ask very difficult questions to ensure procedures are robust. Food operators should not only attempt to comply with legislation but seek to follow best practice.
Meeting US food safety regulations

Andrew Collins of Campden BRI explains the implications of the US Food Safety Modernization Act (FSMA) for businesses importing food into the US.

In the light of the UK’s decision to leave the EU and the current uncertainty as to the exact terms of our trading agreement, businesses will be looking for new market opportunities; the US could be an important potential market.

Involving 2014, outbreaks were reported period September 2013/September 2014, Salmonella (in 18.9% of all cases), Listeria monocytogenes (47.3%). The incidents involving allergens increased from 43.6% in the previous year and if undeclared sulphur at 2.5% are included from 2013/2014, allergens were responsible for over 50% of reported incidents. Concerns over these figures in previous years and significant food safety outbreaks have led the US to develop a risk-based preventive approach to food safety management. The Food Safety Modernisation Act 2011 (FSMA) is the US regulatory food safety requirement. The Act does not apply to all food businesses, only to those regulated by the FDA. The US Department of Agriculture (USDA) regulates cattle, sheep, goats, horses, mules, egg products, poultry, catfish and products containing >3% raw meat or >2% cooked meat.

FDA food safety rules

The FSMA does not include all the details of what businesses must do to comply with the law, so the FDA has written seven rules that provide a risk-based framework for food safety from ‘farm to table’ (Table 1). Companies that export food into the US will need to comply with these rules.

The FSMA requires food businesses engaged in manufacturing, processing, packing or holding of food for consumption in the US to register with the FDA; this must be renewed every two years. The FDA’s enforcement powers have changed from a reactive approach to food safety to a proactive one. It now has the authority to suspend registration if it determines that there is a ‘reasonable probability’ of serious adverse health consequences or death to humans or animals (SAHCODHA).

The Mitigation Strategies to Protect Food Against Intentional Adulteration rule requires businesses to carry out a risk based vulnerability assessment to prevent the intentional adulteration of food from actions that may harm the public. The business would also need to demonstrate the measures taken to reduce or mitigate the likely occurrence of adulteration.

The Foreign Supplier Verification Programme (FSVP) rule is perhaps one of the biggest changes as it imposes an obligation upon the importer, broker or agent to ensure that each food that it imports, that will be consumed in the US, is safe and complies with the regulatory requirements.

The rule requires the importer/broker/agent to evaluate its supplier. This may involve an annual audit, particularly when there is a reasonable risk that a hazard will cause ‘serious adverse health consequences or death to humans or animals’ (a SAHCODHA hazard). The importer is responsible for informing the FDA if there needs to be a recall from the market due to a food safety issue.

This article will focus on some of the requirements of the Preventive Controls for Human Food rule. The Code of Federal Regulations (CFR) Title 21 Part 117. Current good manufacturing practice, hazard analysis, and risk-based preventive controls for human food defines what a food business has to do to comply with the FSMA regulations and requires the business to establish and implement a food safety system. There are some exemptions to this rule and these are laid down in CFR 211.7, more information can be found on the FDA website[1]. The Food Safety Preventive Controls Alliance (FSPCA) is a broad-based public private alliance of industry, academic and government stakeholders, which supports food safe production by developing training and outreach programmes to assist companies producing human and animal food in complying with the preventive controls regulations that are part of the Food Safety Modernisation Act.

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Table 1 FDA rules for food safety from ‘farm to table’

<table>
<thead>
<tr>
<th>Rule</th>
<th>Date published</th>
<th>Web</th>
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<tbody>
<tr>
<td>Mitigation strategies to protect food against intentional adulteration</td>
<td>27/05/2016</td>
<td><a href="https://www.federalregister.gov/articles/2016/05/27/2016-12373/mitigation-strategies-to-protect-food-against-intentional-adulteration">https://www.federalregister.gov/articles/2016/05/27/2016-12373/mitigation-strategies-to-protect-food-against-intentional-adulteration</a></td>
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FOOD SAFETY MODERNIZATION ACT

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The PCQI may be held responsible for a food safety incident as they are seen as a qualified person.

Recall plan
A recall plan must be included in the Food Safety Plan. This has been a requirement in the EU under Regulation (EC) 178/2002. The regulatory guidance EC Commission Notice 2016/C 279/01 has this requirement as part of a company’s preparedness, which would be managed as a prerequisite programme. In the US recalls are categorised as Level 1, where adulterated products are likely to cause serious adverse health consequences or death, Level 2 where products may cause injury but the probability of serious illness or death is remote or unlikely, or Level 3, which would involve products that are not likely to cause injury or illness.

Process preventive controls
The process preventive controls are typically critical control points (CCPs). A CCP is defined in CFR 21 Part 117.3 as a point, step, or procedure in a food process at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce such hazard to an acceptable level. The procedures could also be viewed as Operational Prerequisites (OPRPs). The use of the term ‘preventive controls’ removes any uncertainty about whether a hazard is managed by a CCP or an OPRP.

Food allergen preventive controls
The food allergen preventive controls require actions that prevent cross contact as well as label review, which should ensure that the label has the correct information and that it is applied to the right product.

Sanitation preventive controls
Sanitation preventive controls are required to prevent contamination of the product from the environment, people and equipment.

Supply chain preventive controls
The supply chain preventive controls requirements are defined in CFR 21 Part 117 Sub part G; this section covers the need for effective approved supplier programmes. This may not be a preventive control for all food businesses; it will depend on who makes the product safe. If it is not a preventive control, management will be through the current good manufacturing practices (cGMPs).

The food business will need to determine parameters for all preventive controls; those for the process preventive controls could be critical limits.

The preventive controls will need to be monitored and results will need to be documented. There is also a requirement for corrective action procedures. The terms ‘corrections’ and ‘corrective actions’ are used in the rule; correction is applied when there is no impact on the product safety. This is not the same as definitions used in the ISO 22000 standard. In ISO 22000, corrections are activities that deal with the product and regain control of the process. Preventive actions are activities that prevent the issue from happening again or reduce its likely occurrence.

The Food Safety Plan will need to be verified; verification is defined in CFR 21 Part 117.180 and is a requirement for a food safety incident as they are seen as a qualified person. The re-analysis of the Food Safety Plan. This has this requirement as part of the plan, which the FDA may ask to see.

References and additional information:

- Codex Alimentarius has taken in its Guidelines for the Validation of Food Safety Control Measures (CAC/GL4/2008).
- In this document, Codex defines verification as ‘the application of methods, procedures, tests and other evaluations, additional to monitoring, to determine whether a control measure is or has been operating as intended.’
- Guidance: More guidance is required and is expected in certain areas. For example, although the PCQI does not need to successfully complete a recognised course, there is no clear guidance as to how qualification through job experience can be achieved.

As it is early days regarding the inspections by the regulatory official, we can expect more feedback on compliance requirements.

It is understood that a number of gap analyses have been performed, comparing GFSI (Global Food Safety Initiative) benchmarked standards with the requirements of FSMA. The BRC (British Retail Consortium) offers an FSMA bolt module, which specifically addresses the FSMA requirements. Interest in the requirements of FSMA is growing in the UK and Europe as a whole.
Peace of mind on the menu for allergy sufferers

Food allergy is growing at an alarming rate - UK hospital admissions for food allergies have increased by 500% since 1990[1] with nearly one in five people thought to be suffering from a food allergy or intolerance. It is becoming increasingly apparent that allergies are fast developing into a modern epidemic, so it is now more important than ever to prioritise the safety of customers eating out of home.

Living with a food allergy can be very difficult, both physically and emotionally. For almost half (44%) of allergy sufferers, who live in fear[2] that they will experience a potentially fatal reaction, going out to a restaurant for dinner or popping out to a café for lunch can be a daunting experience.

The catering industry can play an important part in counteracting this fear by demonstrating the highest levels of allergy management to ensure both the safety of their customers and to build confidence in dining out for those living with allergy. A Consumer Eating Habits Survey revealed that 99% of allergy sufferers worry about eating out of home[3].

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Personalised nutrition

A collaborative European Union FP7 project, Food4Me, was one of the first to explore comprehensively the opportunities and challenges of personalised nutrition. Eileen Gibney and other project partners describe the key findings.

Background
The sequencing of the human genome in 2003 was a major breakthrough in science, which many believed had the potential to revolutionise healthcare through the identification of individuals at risk of disease and the development of interventions specific for each individual’s genotype. This gave rise to the concept of personalised nutrition, where tailored dietary advice is delivered to individuals based primarily on genetic factors but also including other personal information, such as current diet and phenotype. This contrasts with most public health advice about diet, which is generic, non-specific healthy eating advice e.g. eat at least five portions of fruit and vegetables daily. Although the original concept of personalised nutrition focused on delivering advice based on genotype, from the outset, Food4Me took a broader view of the factors likely to be important in personalising dietary advice. As proof of principle, three levels of personalisation were chosen, which could be used separately or in combination, i.e. personalised dietary analysis, personalised phenotype analysis and personalised genotype analysis. While there was growing interest in gene-nutrient interactions, which could support the delivery of personalised nutrition, a comprehensive study examining the broader opportunities and challenges was lacking. Food4Me aimed to fill this knowledge gap. It was a multi-partner project funded by the European Union Seventh Framework Programme (FP7), which was the first to explore comprehensively the opportunities and challenges that personalised nutrition could offer, examining business and value creation models, consumer attitudes to personalised nutrition, technology and finally, the ethical and legal implications of personalised nutrition. This article gives an outline of some of the key activities and findings from the Food4Me study.

Value creation concepts for personalised nutrition
Scientific advances may face important barriers in becoming accepted and applied by society, even though benefits may seem obvious to researchers. A fundamentally new development, such as personalised nutrition, is particularly challenging to evaluate because it touches upon two primary human needs: health and food. These are at the heart of a major societal debate as many of today’s public healthcare issues, such as obesity and diabetes, are largely a consequence of inappropriate dietary and lifestyle behaviours.

There is an urgent need to help citizens to adjust their dietary behaviour to enhance their long-term health and well-being. Personalised nutrition offers a new approach by providing advice about healthy food choices and eating patterns to fit an individual’s needs and personal preferences. This inherent link between individual behaviour change and the corresponding societal impact means that the introduction and widespread adoption of personalised nutrition is likely to have significant societal consequences. Value creation models for personalised nutrition are interesting but also very challenging. Personalised nutrition concepts need to integrate different elements, such as personal coaching principles and new technological tools ranging from self-sampling diagnostics, wearable lifestyle and food intake monitoring, to mobile interfaces for dietary coaching. Moreover, personalised nutrition concepts have the potential to substantially improve the value perception of food and its role in health and society. In order to explore future value creation models, it is necessary to consider the future societal context. Four scenarios about evolution of nutrition and health issues in Europe served as a basis to develop 10 very different value creation concepts for personalised nutrition. The extent to which these concepts may be inherently linked to changes in future society was explored.

The work demonstrated that personalised nutrition is a complex but promising concept because the essential goal is to achieve lasting improvements in dietary behaviour and health. It therefore has the potential to relieve the current pressure on healthcare budgets and thus to bring significant benefits to society.

However, personalised nutrition services are unlikely to follow a conventional business model, but will instead require transition dynamics in which societal changes and business model developments occur simultaneously. Thus, public-private partnerships are most likely to be the best vehicle for developing personalised nutrition services. Given the important ethical issues that may arise, policy makers will be required to ensure that regulatory frameworks in place to guarantee privacy of data in addition to freedom of choice. Without this, there is a significant risk that personalised nutrition services will be misused for commercial reasons or by societal actors to exert improper influences on citizens. There will be a need for scientific coherence in the personalised advice provided, because different scientific interpretations of the data will be counterproductive in the same way that contradictory food and dietary advice has caused much confusion in the recent past.

The consumer and personalised nutrition
The Food4Me study adopted a mixed-method approach (combining both qualitative exploratory data research and
quantitative survey research) to understand the consumer’s view of personalised nutrition and to afford the European public a voice in determining best practice in the design and delivery of services. Consumers who took part in the initial focus groups informed us that a first step in attracting users would be to build trust in service providers. Subsequent (second stage) survey results echoed this finding in that direct-to-consumer (D–T–C) personalised nutrition companies were rated lower on trust than government agencies, family doctors and national Departments of Health. Trust in providers could be enhanced in a number of ways, including through provision of data protection guarantees and ensuring that those delivering services are professionally qualified.

Preferences for service delivery were incongruent with theories of behaviour change based on Social Cognitive Theory (SCT)[5]. Consumers indicated that service design and provision should take into account individual goals related to diet, encourage independent choice and put the client (or service consumers) in control. This could be achieved through providing clients with regular feedback and progress in diet and health markers and enabling them to monitor their own progress toward the achievement of pre-set dietary health goals. The way services are delivered may also need to be personalised. Some consumers indicated they would prefer automated feedback, others preferred feedback by telephone or in person. Individual differences in motivations for food choice also need to be taken into account. To ensure a prescribed diet can be adhered to in social settings, advice may need to be adapted not only to the client’s dietary needs but also to their working environment and social circumstances as well as with respect to their partners in food and food-product developers in bringing the benefits of personalised nutrition to the wider public.[6]

**Technology and personalised nutrition**

The Food4Me project conducted a scouting exercise for new technologies and tools for use in nutrition and health monitoring and provided technical support and solutions to the proof of principle study. By definition, any type of service can only be personalised if appropriate information about the individual is available. Personalised nutrition services rely on knowledge of food choices or total food intake usually recorded by food frequency questionnaires and on phenotypic data (such as gender, age, body height, body mass, physical activity). This may be extended to include other measurements, such as blood glucose or cholesterol levels or blood pressure, as surrogate measures of health status. The analysis of genotype, either by profiling specific genetic variants e.g. single nucleotide polymorphisms (SNP) or by exome or whole genome sequencing, is also readily available. Assessment of the individual’s lifestyle – particularly dietary habits and physical activity – provide the closest link to nutrition-related chronic diseases, such as diabetes, coronary heart disease or cancers. Possible nutrient deficiencies or at least intakes below the recommended levels also need to be addressed if identified. Finally, analysis needs to be translated into comprehensive and feasible recommendations for lifestyle changes, which take into account identified (via questionnaires) constraints, such as food allergies and intolerances or simply food dislikes.

Food4Me defined a panel of anthropometric parameters that the participants could record and report themselves when provided with instructions and information, such as videos for the necessary procedures in the languages of the different partner countries. In addition, the practicability of the methods and the validity and coherence of the data collected were assessed. Moreover, a database for validated gene–nutrient–health interactions was developed based on a meta-analysis of published studies and expert knowledge. An automated recommender system and meal coding system was created for the participants and a menu-planning module based on linear programming was developed for future applications in personalised nutrition. It provides a weekly meal plan with concise menu suggestions taking into account the dietary needs and also the food likes and dislikes of each individual.

**Does personalised nutrition work?**

A major undertaking of the Food4Me project has been the completion of a Proof-of-Principle (PoP) Randomised Controlled Trial (RCT) on the implementation of personalised nutrition. The RCT was designed to mimic a real-life internet-based personalised nutrition service and to provide insight into the effectiveness of the advice compared with non-personalised ‘one size fits all’ recommendations. The Food4Me PoP study was a four arm, internet-based, 6-month RCT conducted across seven European countries, which compared the effects of different levels of personalised nutrition on health-related outcomes.[7]

The study posed two primary research questions. First, does personalisation of dietary advice assist and/or motivate participants to eat a healthier diet in comparison with non-personalised, conventional healthy eating guidelines? Second, is personalisation based on individualised phenotypic or genotypic information more effective in motivating participants to make healthy changes, compared to personalisation based on analysis of current diet alone? To answer these questions, participants were randomised to either Level 0 to receive generic, non-personalised dietary advice (control), or to receive one of three levels of personalised dietary advice: based on the participant’s current diet alone (L1), based on current diet and phenotypic data (L2), or based on current diet, phenotypic and genetic data (L3).

The study collected genotypic information at baseline (0 months), and phenotypic measurements (height, weight and dry blood spot samples) and information on diet and lifestyle at 0, 3 and 6 months for all participants. This large RCT, which incorporated several innovative features, including self-collection of blood by the participants using dry blood spot cards, generated a rich dataset, which was interrogated extensively. The principal finding was that participants who received personalised nutritional advice ate significantly healthier diets than the control group, regardless of whether this personalisation was based on their diet alone, their phenotype or their genotype.[8]

These results indicate little added value from using genomic information to personalise lifestyle-based interventions. However, the fact that those receiving personalised nutrition advice reported bigger changes in dietary patterns after 6 months suggests that this advantage may be sustainable. The study also demonstrated that advice delivered via the internet offers promise as a scalable and effective route to improving dietary behaviours, which may have important public health benefits.[9]

Ethical and legal issues surrounding personalised nutrition

To identify and address the ethical issues in relation to personalised nutrition, Food4Me focused on an ethically relevant aspects that distinguish personalised nutrition from other health services. Several areas of special ethical concern were identified in relation to personalised nutrition. The current scientific evidence for personalised nutritional advice is quite limited and fragmented. However, in specific cases of gene–diet interactions, individuals could benefit from following personalised rather than general dietary recommendations. What is an ethically responsible way forward in this situation? Arguing from a precautionary approach, it is suggested that personalised dietary advice should be offered only when there is strong scientific evidence for health benefits, followed by stepwise evaluation of unforeseen behavioural and psychological effects.[10] Another important consideration is whether consumers can be offered personalised nutritional advice over the internet (by way of D–T–C genetic tests) in an ethically and legally safe and sound manner, securing different aspects of consent and data protection. Studies have shown that current D–T–C services for personalised nutrition suffer from a questionable level of truthfulness and an imbalance between far-reaching claims and the effects of personalised advice and contrasting disclaimers. Current regulation in this area is incomplete and therefore there is a need to carefully

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**Best practice will entail treating clients as partners in the design of dietary interventions to promote their health**

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PERSONALISED NUTRITION

PERSONALISED NUTRITION
examine personalised nutrition services offered via the internet in order to develop guidelines and rules that safeguard privacy, consumer protection and safety [10].

Other important questions include whether personalisation of nutrition could negatively affect the social aspects of eating as well as our understanding of health and how a wider use of personalised nutrition may influence solutions to the societal dilemma of individualisation, where the societal goals for individual autonomy and justice may come into conflict with each other.

Personalised nutrition could challenge the current legal situation and create a need for further development of the legal framework. A core result of this analysis is that neither the EU nor its Member States have legal instruments specifically dealing with personalised nutrition. Instead, owing to its nature and characteristics, personalised nutrition falls within the ambit of several legal instruments and the determination of which ones are applicable to any specific personalised nutrition offering necessitates reviewing the components of the proposed service. For instance, currently it is not clear whether personalised nutrition services should be considered as part of healthcare services or should fall under the conventional business-to-consumer (B2C) service contract.

The classification of a personalised nutrition offering as healthcare is dependent on the status of the various professionals involved in the service in a Member State. Such classification has a significant impact on the legal obligations of the professionals involved. Personalised nutrition providers depending on the status of the professionals involved. Personalised nutrition offerings may also involve the use of various devices, such as instruments for self-testing. The current legal framework does not clearly address these new vehicles.

Conclusions
Food4Me has demonstrated that personalised nutrition is emerging as a novel concept that offers exciting alternative approaches to improving dietary behaviours with potential to enhance health and wellbeing and, therefore, to reduce healthcare costs. The Food4Me intervention study demonstrated that personalised nutrition can be feasible and effective and that the delivery of personalised advice and recommendations is more effective in changing dietary intakes than general healthy eating messages. The work demonstrated, however, that successful implementation is not without its challenges. Delivering a full personalised nutrition service will require integration of a wide range of elements, from biomarker, genotype and dietary diagnostics to scientific interpretation algorithms, mobile interfaces, wearable monitoring devices, app development and big-data handling. Consumer trust in such services will be key and will help to shape successful delivery and implementation. Consumer protection and regulation will also be important.

Whilst the Food4Me project demonstrated dietary benefits, society will also have to consider that not everyone may care equally about their health and hence the assumed societal responsibility in maintaining individual health may not be subscribed to by everyone. If implemented at scale and over time, personalised nutrition has the potential to support positive changes in diet and lifestyle and to contribute to a reduction in the societal burden associated with diet-related health problems.
Fuel cells power food operations

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cel produces energy through an electrochemical reaction that uses hydrogen. This combustion-free technology is available today to power a range of applications. With low-to-zero emissions, depending on fuel feedstock, and the additional benefits of high efficiency, reliability and scalability to any power need, fuel cells are finding a niche powering various operations for food manufacturers.

What is a fuel cell?

Fuel cells, first created in 1839 by the UK’s Sir William Grove, were a mainstay in America’s space programme for fifty years, powering Gemini and Apollo rockets and the Space Shuttle. Fuel cells have since moved from outer space to everyday applications. Large fuel cells now act as power plants, located onsite to supply electricity, and in some cases heating and cooling, to large buildings, office complexes and manufacturing facilities; smaller fuel cells power portable, off-grid and mobile applications, such as cars and forklifts.

Fuel cells use hydrogen either directly or reformed within the system. When operating on pure hydrogen in applications, such as cars, forklifts and backup power, there are no greenhouse gas emissions. The only by-products are electricity, heat and water.

When using natural gas to power buildings and production facilities, the emissions are so low that several US states exempt fuel cells from air permitting requirements. The use of biogas can reduce life-cycle emissions to near zero. Many food operations have adopted the use of fuel cell technology, with thousands of fuel cells now supplying power to processing facilities and bakeries, helping to move stock in warehouses and providing reliable energy to supermarkets. They are doing so because of the many benefits of fuel cells:

• Exceptionally reliable and efficient.
• Capable of providing 100% power for as long as fuel is present, even in conditions down to -22°F.
• Virtually silent, reducing noise emissions.
• Scalable, so that by stacking individual fuel cells together, you can generate as little as or much more power as needed.
• Fuel cells operate in water balance, with most fuel cells only requiring less than a gallon per megawatt-hour (MWh).
• Independent operation from the grid, allowing business operations to continue when grid power goes down.

These attributes allow both stationary and mobile fuel cells to be operated indoors or out and permit stationary fuel cells to be sited on rooftops, in basements or adjacent to buildings.

Food processing

Keeping daily operations running efficiently and seamlessly in a processing, production or packaging/bottling facility requires a reliable source of power. Many companies in the food industry are turning to fuel cells to provide electricity, and in some cases heating and/or cooling, to production sites. The list is long and includes such household staples as Coca-Cola, Kellogg’s, Pepperidge Farm, The Wonderful Company and many more.

These companies are finding savings on multiple levels, including emissions reductions, energy costs and water use.

Utilising waste as a source of fuel can further increase savings. Many food and beverage processing facilities, such as wineries and breweries, produce organic waste matter daily. This waste is costly to remove and burdensome to store. One of the technologies being used to convert waste into a usable gas stream is anaerobic digestion. The resulting gas includes hydrogen, which may be purified and used to power a fuel cell, that generates electricity and heat for the plant. If the fuel cell is configured to capture the excess heat, known as a combined heat and power (CHP) system, the efficiency can be as high as 90%.

This is not a new idea. In the late 1990s, several Japanese breweries used the effluent from the brewing process to produce biogas for their fuel cell systems. Other breweries in Germany followed suit. In the US, this process has gained traction in a number of installations at food processing plants and wineries.

Gills Onions, an onion processor in Exدارl, California, installed a 600kW fuel cell system in 2009 to utilise biogas generated from the 300,000 pounds of onion waste it generates per day. The fuel cell powers the facility and provides some of the heat for the conversion process. Gills not only has lowered electricity costs, but has saved money on waste removal. The company also sells the leftover pulp as cattle feed.

Looking further afield, researchers are generating hydrogen from tempeh and tofu processing waste[1] and have investigated sources, such as peanut shells[2] and even candy[3]. A winery in California is already using naturally occurring bacteria and a small amount of electricity to extract hydrogen from the wastewater it generates from wine making.

Distribution centres

Fuel cells are well-suited for low-temperature operation in refrigerated storage facilities and freezers, making the technology ideal for moving food products in supermarkets, foodservice distributors and food processor operations. Today, more than 16,000 fuel cell-powered forklifts operate in US warehouses, including many in food logistics operations – Coca-Cola, Nestle Waters, Newark Farmier’s Market, Sysco, Walmart, Wegmans, Whole Foods Market, and many more.

These companies are taking advantage of the strong business case for fuel cells, which includes cost, performance and productivity benefits. The US Department of Energy (DOE) reports that, compared to battery forklifts, fuel cell forklifts have a lower total cost of ownership, an 80% lower refueling labour cost and take up 75% less warehouse space compared to battery charging infrastructure[4]. The fuel cell cost advantage per unit is increased by $2,000 per year for forkilf for the average high-use facility[4]. Additional benefits include meeting or exceeding performance requirements in sub-zero warehouse temperatures, delivering constant power during the shift with no performance lags and refueling in minutes using a hydrogen dispenser. Since there is no need to change a battery for recharging, operator down time is significantly reduced and valuable warehouse space used for battery storage can be returned to active use. DOE reports that fuel cell-powered lift trucks operating on hydrogen made onsite from natural gas have about 33% fewer greenhouse gas emissions than lift trucks powered by batteries or liquefied petroleum gas (LPG).

Over the past year, three European companies have announced plans to use fuel cells to their forklift fleets, adding up to more than 480 fuel cell units.

• The Belgian grocery chain Colruyt is expanding its demonstration fuel cell forklift fleet from 13 to 200 at its Haal, Belgium facility. The company produces its own hydrogen onsite using renewable energy from wind turbines and solar panels located at the distribution centre. The hydrogen station is also equipped with a fuel cell system that produces power when energy production from the wind and solar resources is low.

• Plessence, a French logistics service company that focuses on the fruit and vegetable market, expanded its original 35 fuel cell forklifts at its Orléans facility to 46 units in 2016, with plans to increase to 40 fuel cell units in 2017. The company saves an estimated $337,000-$450,000 a year in equipment costs due to the elimination of the battery storage, charging and changing facility.

• French retailer Carrefour, which owns one of the largest hypermarket chains in the world has purchased more than 150 fuel cell units to be deployed in Class II and III electric lift trucks at its new distribution centre located in Vendin-lès-
Béthune, France.

The use of fuel cells goes well beyond forklifts. The US DOE is currently funding a demonstration project to determine the feasibility of fuel cell-powered refrigerated transport units (TRUs) to replace diesel-powered internal combustion engines, currently used on trucks transporting refrigerated and frozen products.

**Grocers**

Grocery stores are intensive energy users. After labour costs, energy costs are the most significant portion of the annual operating budget for the grocery retail sector. In a typical US store, refrigeration and lighting comprise about 80% of total electricity use and space, heating accounts for 68% of natural gas use.

Most of this energy is delivered through traditional power generation, with a significant portion of the energy lost as heat. But this waste heat can be turned into usable energy through the use of CHP, where electricity is produced onsite and the exhaust heat is captured for the provision of heat, hot water and cooling. By providing more efficient energy use, CHP fuel cells have the potential to reduce electricity and natural gas costs for a facility. US grocery chains Whole Foods Market, Shop & Shop, Haggen, Safeway and Price Chopper operate fuel cell systems at several of their retail stores, generating 50-70% of the necessary power and heat onsite.

The high reliability of fuel cells makes them an attractive power generation technology for businesses that customers rely on. By producing power onsite, fuel cells ensure continuity of power generation, allowing a grocery store to remain open to shoppers when grid power loss has closed down other businesses. This helps protect refrigerated and frozen foods from spoilage and waste and eliminates the need to send out a backup generator to power critical loads, store fresh items in a refrigerated truck, or to pack goods in dry ice to preserve them.

There are several real-world examples to point to. During Superstorm Sandy (October 2012), fuel cell systems kept grocery stores in Colonie, New York and Middletown, Connecticut, up and running, supporting critical operations for 5-6 days when grid power was completely down. Another fuel cell provided a Terrington, Connecticut, grocer with power, heat and cooling when grid power was intermittent due to the storm. In 2011, a San Diego, California, grocery store equipped with a fuel cell was one of the few businesses operating during a grid blackout. Besides these impressive capabilities, fuel cells emit almost no pollutants, allowing them to be exempted from air permitting requirements. Other than an initial injection of water into the system, fuel cells also consume no water during operation, saving on water costs.

Other food businesses are using fuel cells to lower emissions. Global cold storage provider for the fish and agricultural industries, AmeriCold, operates a 600-kW fuel cell system at its Salinas, California, warehouse to lower its electricity costs and cut greenhouse gas emissions. The fuel cell supplies 5.4 million kilowatt hours of clean and reliable power annually.

**Fuel Cells**

FUEL CELLS

By producing power onsite, fuel cells provide businesses that customers rely on. Fuel Cells Canada (FCC) provides a consistent industry voice to regulators and policymakers. Fuel Cells Canada (FCC) provides a consistent industry voice to regulators and policymakers.

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Most people remember that at school there was never an option to study horticulture. Teachers knew nothing of the opportunities available. The UK governmental careers advice service, Connexions, which was disbanded in 2011, seemed to largely direct pupils into the recognised professional career paths, such as law, teaching and nursing.

Grow Careers Website
After identifying both the skills crisis and the aging workforce within the horticulture industry, a large group of influential organisations in the horticulture sector decided that something had to be done. Grow Careers was created to address this lack of horticultural careers advice for young people. One of the main issues is that careers in horticulture still have a very poor image of low pay, muddy fingernails and back breaking work. However, this not the case and the Grow Careers portal was set up to show all the fantastically varied and skilled careers that are available in the industry.

The Grow Careers vision is to be a clear, inspiring source of information for those entering, or progressing within, the horticulture industry. Its mission is to both increase the number of new entrants into the sector and inform the progression and diversification of careers within the industry. It aims to achieve this through the promotion of horticulture as an exciting and dynamic career to both potential entrants and those that influence them, by providing easily accessible careers information across the sector.

The impact of Brexit is making it more important than ever for the UK to be able to encourage and nurture young horticulturists. Recent research from the Horticultural Trades Association estimates that amongst its members the impact of Brexit is making it more important than ever for the UK to be able to encourage and nurture young horticulturists. Recent research from the Horticultural Trades Association estimates that amongst its commercial grower members, up to a third of the workforce is made up of non-UK, EU nationals. EU nationals are heavily represented in the seasonal workforce. At present many employers within the sector take advantage of freedom of movement - which allows any EU citizen to live and work freely across the EU - by employing staff from across the European Union, as either full time or seasonal workers [1].

Competitions
There are several schemes and competitions being run all over the country with the aim of encouraging young people to find out about horticulture and what it can offer. The RHS ‘Green Plan It’ competition has had great success after it was introduced towards the end of last year in schools all over the country. The Green Plan It Challenge is a 10-week project for Year 8-9/ S2-3 students encouraging them to rethink the role of green spaces, either in their own school or their local community [2].

The Chartered Institute of Horticulture runs the ‘Young Horticulturist of the Year’ competition annually, which attracts around 2000 applications from all over the country from those under the age of 30. It gives young people the opportunity to compete for a £2,500 bursary to travel the world and study horticulture in a completely new way [3].

The horticulture sector needs to unite its efforts to make this work. The Ornamental Horticulture Roundtable Group was formed in 2014, as an industry–government partnership to identify and address key issues for growth. Careers promotion and education are central to the Action Plan produced in 2015 [11].

Government Post-16 Skills Plan
With an educational environment where teachers are sometimes having to encourage students to stay on at school and study academic subjects to keep their funding for those subjects, technical and vocational options are taking a hit. The good news is that a new government initiative means that in 2019, new technical and vocational qualifications will be introduced into the post-16 education skills plan.

According to a recent statement by the Department for Business, Innovation & Skills, Department for Education and Nick Boles MP, Thousands of ineffective courses that short-change employers and young people will be replaced with 15 straightforward routes into technical employment creating a more skilled workforce fit for modern Britain [9].

The proposed routes, including agriculture, horticulture and animal care, will last two years and will be overseen by the Institute for Apprenticeships [4].

Opportunity
The horticultural industry needs to take this opportunity to positively redefine its requirements through collaboration across all sectors. This will ensure that the Grow Careers initiative reflects the needs of the industry and supports its workers, old and new.

Grow Careers events will encourage young people to find out what is involved in a horticultural career and will promote discussion with key figures in the industry, who have worked their way up through the ranks and have a true passion for what they do. Government guidance for educational establishments should also help to encourage young people to pursue a horticultural path.

References and article available online at: www.fstjournal.org/features/31-2/careers-training/growing-careers

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This book intends to provide insight into the most promising Emerging Technologies in Meat Processing and provide comprehensive coverage of novel processing, packaging and assessment methods for meat and meat products.

It is aimed at academic, industrial, nutrition and health professionals. The book consists of a number of published papers in three sections: novel processing techniques; novel packaging and meat functionality; and assessment techniques for meat quality and safety.

The contributions provide a number of well researched chapters, which will be of use to the target audience, although to open with a paper on irradiation of meat and meat products does not fulfil the brief of ‘most promising technologies’. This was an emerging technology when I was a food technology undergraduate 50 years ago and is not approved for meat and meat products in Europe currently; other techniques described are likely to be more practical. The authors of this chapter seem to be frustrated advocates of the technology that would be effective if only public opinion could be changed. This is not to detract from the overall value of the book, which could lead to further developments of some of these technologies by industry or research by academic institutions. Any of the technologies could have potential as new food safety threats emerge, especially as antibiotics are proving less and less effective.

Although the opening chapter by the editors specifically addresses the objective of reviewing meat processing technologies and the reasons for doing so, a number of the technologies described are applicable to a wide range of foodstuffs, not just meat, and this could have been reflected in the title to make it more widely read.

The technologies described in Part I cover a wide and interesting range, from the speculative to the practical and relevant area of robotics. Part II strangely covers both novel packaging and meat functionality. This provides a useful guide to existing techniques exploring how they could be developed using nanotechnology, with a final chapter on probiotic functionality in meat.

Part III contains some interesting papers on assessment techniques, both laboratory based and in-line, as well as a paper on the topical area of meat authenticity.

The final chapter on regulation and legislative issues does provide a useful context to the potential worldwide application of new technologies.

Overall the book is well put together and well indexed with very few typographical errors.
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