Food manufacturing

Smart factories

ALSO
- Automated food manufacturing
- Robotic chef
- Open Innovation
- Centre for Innovative Manufacturing in Food
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- Supply chain threats
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WHOSE PESTICIDE ANALYZER
Climate change challenges

The climate change challenges facing the UK are outlined in the government’s latest Climate Change Risk Assessment, published in January 2017 [1]. The changing climate is recognised as one of the most serious environmental challenges and the government is taking action to address this by improving flood defences and securing critical food and water supplies.

The report recognises how the trend towards warmer winters, hotter summers and changing rainfall patterns is affecting communities across the UK and sets out the government’s ongoing investment and work programme to tackle these risks.

Since the first National Adaptation Programme in July 2013, the UK has made progress in a number of areas, for example by:

- Placing a new resilience duty on Ofwat through the Water Act 2014 and publishing the Enabling Resilience in the Water Sector report to ensure the long-term resilience of water and sewerage services.
- Working closely with the food industry to ensure the security and resilience of food supply, using the latest technology delivered through the new Agri-Tech Innovation Centres.
- Constructing a UK Plant Health Risk Register to compare the risks posed by different plant pests and pathogens.
- Committing to develop a 25-year environment plan that takes climate change into account.

The Climate Change Risk Assessment will be followed by the National Adaptation Programme to be published in 2018.

Alongside the strategy to adapt to climate change risks, the government is also tackling the causes of climate change and trying to reduce the threat it poses to our national and economic security, for example by ratifying the Paris Agreement, the ambitious global deal to cut CO₂ emissions to help accelerate global action on climate change.

Robot packers

Ocado, the online grocery retailer, is testing a robotic hand that can pick and pack fruit and vegetables [2]. Ocado already uses a variety of robots in its operations, but the variation in shape and fragile nature of fruit and vegetables mean that they have been susceptible to damage or bruising when handled by existing robots.

The company has tested the RBO Hand 2 developed by the Technische Universität in Berlin with two different robotic arms: the LBR iwa14, an ‘intelligent industrial work assistant’ designed by German robotics firm Kuka to work closely with humans, and the Staubli RX160L, an industrial robot assistant ‘designed for harsh environments’.

Ocado is also using machine learning and 3D ‘computer vision’ to create its own robotic hand with the ability to grab a range of tricky objects including eggs, glass bottles and household cleaning products, such as bleach, that could be hazardous if spilled. It is trying to train the hand to recognise when fruit is ripe or mouldy. The aim is to be able to deal with a wide range of objects.

Another Ocado development project is a humanoid robot, SecondHands, which uses machine learning to provide assistance to human technicians carrying out warehouse maintenance tasks. The company has already been able to increase the productivity of its staff by 50% by improving the systems that bring goods to packers.
Categorisation of food scares

The food sector is now a world market with products sourced from all over the globe to meet the growing demand from consumers for diverse food stuffs regardless of seasonality. Fulfilling this demand has led to the creation of complex food supply chains, which have limited traceability and accountability mechanisms, increasing the likelihood of food scares.

Researchers at the University of Surrey worked with industry experts to develop a new comprehensive categorisation of food scares [1], having found that existing schemes were too simplistic and did not allow for cross categorisation of factors, which could compromise the food chain. The new categorisation could be useful in developing strategies for reducing the frequency and severity of scares.

Unlike previous systems, the new categorisation structure enables a food scare to be classified according to both its physical manifestation (chemical/physical or biological contamination) and the origins of the scare (wilful deception and/or transparency and awareness issues). By highlighting where and how the nature of different types of food scares overlap, this classification will enable risk management teams to address categories of potential scares in a systematic way and develop effective strategies to avoid future occurrences.

During the study the researchers also found current definitions of the term ‘food scare’ to be inadequate as they fail to acknowledge consumers’ lack of trust in the food chain. Researchers pointed to the 2013 horse meat scandal, which although was not harmful for human consumption, created a wariness amongst consumers of the food and supply chain. Consequently, they developed a new definition of a food scare, which takes into account the fact that consumer purchasing decisions elevate a food incident to a food scare: ‘A food scare is the response to a food incident (real or perceived) that causes a sudden disruption to the food supply chain and to food consumption patterns.’

Hidden dangers of supplements

A team of specialists, including Emeritus Professor Duncan Burns, a forensically experienced analytical chemist from Queen’s University Belfast’s Institute for Global Food Security, Dr Michael Walker from the Government Chemist Programme at LGC and Professor Declan Naughton from Kingston University, has been examining the detection of illegal ingredients in herbal dietary supplements [4].

Using techniques, such as datamining, the review looked at research from right across the globe and questioned the purity of herbal food supplements. The research found that over-the-counter supplements – commonly advertised to treat obesity and erectile dysfunction problems – are labelled as fully herbal but often include potentially dangerous pharmaceutical ingredients, which are not listed on the label.

The survey raises serious questions about the safety of slimming supplements containing Sibutramine. Sibutramine was licensed as the medicine Reducitil until 2010, when it was withdrawn across Europe and the US due to an increased risk of heart attacks and strokes associated with the use of the drug.

‘Gene-silencing’ for crop protection

Researchers at the University of Surrey and University of Queensland have developed a revolutionary new crop protection technique [5]. They have found that by combining clay nanoparticles with designer ‘RNAs’ (molecules with essential roles in gene biology), it is possible to silence certain genes within plants. The spray they have developed – known as BioClay – has been shown to give plants virus protection for at least 20 days following a single application. When sprayed with BioClay, the plant ‘thinks’ it is being attacked by a disease or pest insect and responds by protecting itself.

The latest research overcomes the instability of ‘naked’ RNAs sprayed on plants, which has previously prevented them from being used effectively for virus protection. When the agents are loaded on to clay nanoparticles, they do not wash off, enabling them to be released over an extended period of time before degrading.

The BioClay technology, which is based on nanoparticles used in the development of human drug treatments, has a number of advantages over existing chemical-based pesticides. Since BioClay is non-toxic and degradable, there is less risk to the environment and human health. It can also be used in a highly targeted way to protect crops against specific pathogens.

Plant pests and pathogens are estimated to reduce global crop yields by 30 to 40% a year, constraining global food security. At the same time, the need for higher production, regulatory demands, pesticide resistance and concern about global warming driving the spread of disease all mean there is a growing need for new approaches to crop protection.
Recycling plastic packaging

The New Plastics Economy initiative launched its latest report in January 2017 at the World Economic Forum Annual Meeting in Davos. Endorsed by more than 40 industry leaders, it provides a global action plan to transition towards a plastics system aligned with the principles of the circular economy.

The New Plastics Economy focuses on five interlinked and mutually reinforcing building blocks to create the enabling conditions for a transformative system shift: Dialogue Mechanism, Global Plastics Protocol, Innovation Moonshots, Evidence Base and Stakeholder Engagement. Since its inception, the initiative has made significant progress across all these key elements.

This latest research, developed by the World Economic Forum and the Ellen MacArthur Foundation with analytical support from SYSTEMIQ, provides a clear transition strategy for the global plastics industry to design better packaging, increase recycling rates and introduce new models for making better use of packaging. Plastics was identified through initial work by the Ellen MacArthur Foundation, the World Economic Forum and McKinsey & Company as one of the five value chains most representative of the current linear model. Taking a global, cross-sectoral approach to material flows, the Foundation is bringing together organisations from across the five value chains to tackle systemic stalemates that cannot be overcome in isolation.

The New Plastics Economy: Call to Action report was one of the first key deliverables of the New Plastics Economy initiative and provides a global action plan to move towards 70% reuse and recycling of plastic packaging, while highlighting the need for fundamental redesign and innovation of the remaining 30%.

Thorough analytical work, including a detailed segment-by-segment analysis of the plastic packaging market, numerous interactions with players across the plastics value chain and discussions with experts revealed that a programme of concerted action across three key areas could trigger an accelerated transition towards the New Plastics Economy:

- **Without fundamental redesign and innovation, about 30% of plastic packaging will never be reused or recycled.**
- **For at least 20% of plastic packaging, reuse provides an economically attractive opportunity.**
- **With concerted efforts to redesign packaging and the systems for managing it after use, recycling would be economically attractive for the remaining 50% of plastic packaging.**

Policy makers continue to broaden and refine regulations for plastics, introducing landmark legislation worldwide throughout 2016, such as restrictions and bans on single-use plastic (carrier) bags. The European Commission is planning to publish a strategy on plastics by the end of 2017 as part of its Circular Economy Action Plan.

Sandwiches for the homeless

Thousands of tonnes of food that might otherwise have gone to waste could now become available for feeding the homeless, vulnerable and needy in society following an agreement between the British Sandwich & Food to Go Association (BSA) and Government agencies (Food Standards Agency and the Department of Food & Rural Affairs). This agreement will allow retailers to relabel short shelf-life chilled foods for charity use, provided they are satisfied about the safety of products and undertake appropriate microbial shelf-life testing. New guidance has been produced under the BSA’s primary authority agreement with Slough Borough Council, which sets new rules nationally for making donations.

Until now, the law was interpreted to mean that at midnight on the stated date all sandwiches and other food carrying a ‘use-by’ date had to be destroyed. However, supermarket sandwiches undergo rigorous shelf-life testing and are generally fine for consumption beyond the use-by date. Research across five leading retailers shows that this change in how the law is interpreted will potentially save some 2000 tonnes of products going to waste each year. Based on this the BSA estimates that the industry could divert up to three times that tonnage to charities in future. However, retailers and the charities they support will need to establish the practical means to deliver surplus foods to those who need them. While the agreement specifically relates to sandwiches and food-to-go products, its implications could be much wider across the food industry.
IFST News

IFST Spring Conference 2017

With the stimulating title ‘Your Future Role in Food: Embracing Advances in Technology’, our Spring Conference will take place on 7 April 2017 at King’s College – The Strand, London. We aim to highlight advances in technologies – many of which are usually seen as outside the normal scope of food science and technology. This will be an excellent opportunity to explore with us how food production from farm to fork is changing through new science and technology and, in turn, how we can expect roles in the sector to change.

We have a fantastic line up of high-profile speakers so join us to benefit from a day of learning, networking and debate.

If you would like to register to attend this event, please visit http://www.ifst.org/events/ifst-spring-conference-2017-your-future-role-food-embracing-advances-technology

IFST Annual AGM

The 53rd IFST Annual General Meeting will take place on 14 March 2017 from 17.30 at University College Birmingham, McIntyre House, Room 223, 2 Holland Street, Birmingham B3 1PW.

The meeting is open to Members and Fellows to receive the Financial Statements for the year ended 30 September 2016 and the report from the Independent Assessor, to note the election of President and Honorary Treasurer and the appointment of Trustees and Auditors and to consider proposals to update the company Articles.

For further information and to confirm your attendance, please contact Andrew Gardner at a.gardner@ifst.org.

Hygienic Design in Food Processing Environments Conference 2017

IFST’s Western Branch and UK: IE EHEDG have brought together a range of experts who will meet on 23 March 2017 to provide current and future food industry professionals with up-to-date information on new and best practices with regard to hygienic design for the production environment.

For more information and to book your place, please visit http://www.ifst.org/events/hygienic-design-food-processing-environments-0

It’s Not Always Just About the Flavour!

The Sensory Science Group is very pleased to announce that its annual one-day interactive conference will be held on 22 May 2017 in Nottingham. It will take a fresh look at the sensory modalities: appearance, aroma, flavour, texture and aftertase.

The event will comprise presentations, workshops and posters. Speakers from academia and industry will highlight new developments in our understanding of how the sensory modalities are perceived, explore the practicalities involved in making assessments and measurements, and assess the role of new techniques in improving our understanding of how the modalities interact to create our overall product experience.

For more information and to register, please visit http://www.ifst.org/events/it’s-not-always-just-about-flavour

Young Scientist Competitions 2017

Following on from the success of the four Young Scientist Competitions in 2016, we are pleased to announce that this year we will be hosting the competition in all of our regions.

This competition offers undergraduate/postgraduate students (UK only) the opportunity to present their current or recently completed food-related project in front of their peers and to a panel of food professionals.

It is the perfect opportunity to find out more about IFST and the benefits of being a member and of course a great opportunity to network with fellow students and people who are working in the food industry.

For more information about the competition, please visit www.ifst.org/communities-students-competitions-and-awards/young-scientist-competitions-regional
IFST accredits undergraduate degree programmes

Three Bachelor programmes from the University of Reading are the latest to be accredited under the IFST degree accreditation scheme. IFST established the scheme, involving the food sector and employers as well as academics in its design and specification, in response to the needs of the sector to identify the most relevant food science and technology degrees. Since launching in May 2015, 32 programmes at Bachelor and Masters levels have been successful and many others are undergoing assessment.

Professor Carol Phillips, chair of IFST Education and Career Committee, explained that the aim of the scheme is twofold: it helps students decide which degree programmes to consider and it helps sector employers identify suitably qualified graduates. There is fantastic range of food- and non-food-related degree programmes at undergraduate and postgraduate level, she said, 'but not all of them enable graduates to slip seamlessly into a professional food science and technology career. A degree accredited by IFST tells potential students that the programme meets the requirements of future employers. Employers, on the other hand, know that graduates of IFST accredited programmes possess the most important knowledge, skills and behaviours, the foundation of becoming a food science and technology professional.'

According to Andrew Gardner, IFST Operations Director, the scheme has taken off faster than anticipated, demonstrating a growing need for universities to show potential students and employers how their programmes translate into the real world of food science and technology. IFST considers applications in May and November each year.

For further details, a list of accredited programmes and details of how to apply, please visit http://www.ifst.org/accreditation/accreditation-degree-courses

Support the next generation of food scientists

Under the Love Food Love Science banner, IFST is developing a suite of services for teachers to support the new GCSE in Food Preparation and Nutrition.

If you would like to take part in the project, perhaps by sharing your expertise and real-world experience with teachers or by helping IFST develop teaching materials for the new website, register your interest with Andrew Gardner via a.gardner@ifst.org.

Communicate with fellow branch members more easily

The Northern Ireland and Scotland Branches are the first to pilot a new way of communicating with members in the region more regularly. In mid-January we launched a forum for each Branch to enable them to alert their members directly about events and activities. So far it has proved to be successful in disseminating information quickly! We will be opening up the forums to other Branches in April.

Parliamentary Office of Science and Technology Fellowship

IFST is encouraging all PhD students interested in spending a three-month period in the Parliamentary Office of Science and Technology at the Houses of Parliament, Westminster, working on science-based projects to apply for the POST Fellowship.

This bursary will provide a tremendous opportunity for you to gain experience in science writing and an insight into how Parliament functions. IFST will support the Fellow by providing funding of £5,000 to cover a 3-month extension to their PhD award, maintenance and accommodation. The closing date for applications is 10 May 2017.

For more information, please visit http://www.ifst.org/communities-students-prizes-and-awards/post-fellowship
Northern Ireland Branch – New Chairman

We are delighted to announce that Dominic Darby has been appointed as the Chairman of IFST’s Northern Ireland Branch. Here he tells us more about his role and plans for the next 12 months.

Congratulations on becoming Chair of the Northern Ireland Branch. Tell us more about what you hope to achieve in the next 12 months.

I hope that in 2017 the Branch continues to build on the fantastic events we’ve held over the past few years. We’ve been really lucky to have so many great committee members who believe passionately in creating value for the wider Northern Ireland membership and this was recognised in no better way than with our Jack Pearce Memorial lecture in February, which honoured Jack’s fantastic contribution over many decades to Northern Ireland and the wider UK food industry. We also want to host other great events that will appeal to the wider membership across the region with topics that are relevant and beneficial to their continued professional development.

Why is it important to host events for students like the Student LaunchPads?
We’re in a lucky position in Northern Ireland to have three universities offering food science degrees and as a country we produce some fantastic talent. The branch recognised this through our student competition in May, which is entering its 5th year, and through our plans to host our third Student Launchpad in November. These events allow for great networking and mentoring opportunities for students from the more experienced members of the region. It also gives employers direct insight into the most talented, with the winners and runners up of the student competition being snapped up by local companies.

You were recently elected a Fellow of the Institute. Why is it so important to be a member of a professional body like IFST?
Being a Fellow is a fantastic honour, which I’m very proud to have been given last year. It’s been my belief over the 15 years that I’ve been working in the food industry that you get back what you put in and that actively managing your own career is key to progression. Having professional accreditation is recognition of the hard work, training and continual development that food scientists undergo to remain professional and science-led in their roles within the industry.

What do you most enjoy about your current role?
If you mean job role...At the moment I’m working for myself as a consultant in food science and innovation, a role that gives me great freedom and diversity to work with different companies and on many different projects. One such project is work that I’m doing for Marks and Spencer to create a step change in the quality of their retail sushi range through innovation in equipment, raw material sourcing and manufacturing standards. This included a sourcing trip to Japan last summer, outlining the lengths to which companies, such as M&S, will go to ensure authenticity and excellence.

If you mean chairman role...There have been many fantastic Chairs of the Northern Ireland branch, many of whom went on to be President of IFST so I’m very conscious that I have big shoes to fill. What I enjoy the most is that the committee is like one big family and I’ve always had their help, support and guidance, which is part of the reason I was happy to take on the role of Chairman. We’ve recently had some new members join, including some younger people at the start of their careers, which I hope will continue to build on the dynamic and forward looking branch objectives.

What advice would you give to someone starting out in their career?
The advice that I give to students at the mentoring sessions I host at the Student Launchpad is that experience is everything. Most of them will leave university with an excellent level of knowledge but the thing that will separate them from others will be their experience. Whether it’s voluntary or paid work in or out of the food industry, these roles give them the opportunity to develop important employability skills, such as effective communication, leadership and resilience. All the things employers want in future talent. I also tell them that having a genuine love and passion for food and the industry in which they will spend the next 30 work years is important.

Tell us something that few people know
Normally I’m juggling running my own business and spending time with my wife and four fantastic children, but when I have the time, I love to cook and experiment with food. Not many people know but I’ve been known to cure and smoke some great smoked salmon and in 2017 I want to learn some new techniques, such as pickling and fermenting.

Reconnecting with IFST’s North of England Branch

The North of England region is a diverse, vibrant network of members, connected by geography, a passion for food and drink and a love of science! The counties in the North of England have for many years provided food science education and training at the many esteemed centres of learning as well as employment and career development within the food production businesses right across the region.

A handful of members have already expressed an interest in establishing a vibrant network for the support and guidance of any member, in education or industry across the region, by getting the North of England Branch up and running again. We are particularly looking to focus on three areas to begin with - North East, North West and Yorkshire – and would like to hear from members who are interested in helping out in these areas even by just suggesting ideas for ways in which the North of England Branch could be useful to you in your current role.

For more information, please contact Erin Taylor at e.taylor@ifst.org. Please state which area you would be interested in finding out more about.
Colour degradation and bioactive potential of raspberries for fruit snacks

Freeze-dried raspberries had a higher retention of bioactive compounds and a lower content of polymeric compounds than air-dried ones. Dried samples without wet and dry sugar infusion pretreatment showed the highest retention of total phenolic content (freeze-dried =82% and air-dried =37% retention), but the lowest sensory acceptability. Although sugar infusion pretreatments caused an important loss of bioactive compounds (9–18% of TPC retention), they had a higher sensorial acceptability. Pretreatments with bisulphite and acid gave the highest anthocyanin and polyphenol content, antiradical activity and colour retention.

Sette et al., 2017, doi:10.1111/ijfs.13283

Preservation of the functional quality and colour of carrot juice

Acidification (at pH 4.5, 5.0, 5.5) and mild thermal treatments (56, 58, 60°C) of carrot juice at different exposure times (2, 4, 6 min) resulted in higher α- and β-carotene concentrations than in untreated juice due to an increase in the extractability during processing. Thermal treatments were the most influential at increasing carotenes. Conversely, total antioxidant activity (TAA) was more affected by pH. The maximum TAA was observed at pH 4.5 at 56°C. Moreover, samples with the lowest pH were the most luminous. The combination of pH 4.5 at 60°C for 4 min showed high carotene concentrations and high TAA, resulting a good alternative to improve the functional quality and colour of carrot juice.

Ferrario et al., 2017, doi:10.1111/ijfs.13348

Stabilising beverage emulsions

This study compared the efficiency of three different food-grade emulsifiers to form and stabilise an orange oil-in-water emulsion for a beverage. The emulsifier type and concentration had a profound effect on the initial particle size of the oil droplets, with Tween 80 being the most effective at reducing the particle size (1% w/w, 1.88 ± 0.01 μm), followed by sodium caseinate (10% w/w, 2.14 ± 0.03 μm) and gum arabic (10% w/w, 4.10 ± 0.24 μm). Turbiscan analysis measured stability indices after 4 weeks of storage of the concentrated beverages in the following order: Tween 80 (1.70 ± 0.08) < gum arabic (4.83 ± 0.53) < sodium caseinate (6.20 ± 1.56).

The protein emulsifier was more able to control the oxidation process and this was attributed to the excess amount of emulsifier present in the aqueous phase.

Raikos et al., 2017, doi:10.1111/ijfs.13286

To submit a research paper to IFST visit https://mc.manuscriptcentral.com/ijfst
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• Jean Murray Csci, Company Microbiologist - William Grant & Sons Distillers
• Ravi Cherma CSci, Director of Quality Assurance - Kerry USA

Registered Professional Food Auditors and Mentors
• Stephen Spice RPFAM, Director - Spire Food Consultancy

Registered Food Safety Managers
• Stephen Spice RFoodSM, Director - Spire Food Consultancy

Registered Food Safety Principals
• Ravi Cherma RFoodSP, Director of Quality Assurance - Kerry USA
The UK food and drink industry has a great deal to feel positive about. According to data from the industry body, the FDF (Food and Drink Federation), it is the UK’s largest manufacturing sector, accounting for 16% of total manufacturing turnover. The sector employs over 400,000 people and has over 6,600 businesses – 96% of which are micro to medium-sized. It is also one of the UK’s best performing manufacturing sectors: annual gross value added (GVA) to the UK economy is £22bn, almost as much as automotive and aerospace combined. In the last decade, annual exports have doubled, to around £13bn – bucking a decline in total UK exports. Productivity too has increased by 11% over the last five years, compared to an overall UK productivity increase during the same period of just 0.5%.

At the same time, for all its apparent health, the sector still faces significant challenges. Skills shortages and an ageing workforce means it needs to attract around 120,000 new recruits over the next decade. In common with other UK manufacturing sectors, it is finding it increasingly difficult to recruit the high calibre, skilled workforce it needs to drive innovation, particularly engineers and scientists. While productivity growth is ahead of the average, it still lags behind manufacturing sectors with smaller workforces and greater levels of automation, such as automotive, aerospace and rail. GVA per employee is higher than many of its European counterparts, including Germany, Italy, Spain and France, but is still less than half of that in the US. Productivity growth has also experienced a slowdown since the global financial crisis of 2007-2009, as investment in automation has stalled and falling output has not been matched by reductions in labour hours worked.

Smart factories

As the economy recovers and the advances in intelligent connectivity and automation technologies offered by Industry 4.0, the Industrial Internet of Things (IIoT), and smart machines and factories begin to be realised, the UK’s food and drink manufacturing industry faces an opportunity to make a major productivity step change. For engineering leaders in this vital sector looking to remain competitive in the UK’s ever-challenging supply chain, understanding how to maximise this golden opportunity to grow and develop their businesses and organisations through better plant, productivity, process and people will be crucial.

If the food and drink sector can successfully realise and unlock its potential, the collective opportunity that Industry 4.0 and the increased digitalisation of manufacturing offers is exciting and substantial. Connecting all the elements of the plant and supply chain together will deliver capabilities for faster, more diverse, more flexible and more intelligent production, together with increased energy efficiency, reduced wastage, closer links to logistics processes and an optimised value chain. Systems and components exchanging information to control and regulate themselves will also substantially increase the potential for leaner production, condition monitoring and predictive maintenance.

Partnerships

Another trend industry observers have noted is that there is more and more collaboration taking place between industry players. Partners are combining their varied expertise to offer manufacturers and machine builders increased flexibility, improved connectivity and communications, and mass customisation capabilities. These partnerships are designed to deliver improved automation and reduced labour costs through better plant
and production equipment.
One such example is a recent collaboration combining linear motor and mechanical guidance technology from Festo, with Siemens' extensive controls expertise, to create an adaptable, modular transport solution, the Multi-Carrier-System (MCS). Easily incorporated into existing production and packaging environments, it addresses an acute need for flexibility in modern manufacturing environments, driven by increasingly complex product diversity, shorter product life cycles and growing levels of mass customisation. Its configurable linear transport rail can be integrated into existing intralogistics and standard conveyor systems, with precise synchronisation and seamless infeed and outfeed of transport carriers. Movement of carriers can be rapidly adapted to deal with different formats, sizes and types of product – down to batch sizes of one, or even to handle seasonal variations.

Incorporating decentralised sensors and intelligence, its flexible electromechanical design enables adaptable, reconfigurable and economic production, even for mixed requirements and small batch sizes. It also benefits from an OPC-UA interface, enabling easy integration into Industry 4.0 host environments. Validating the success of the collaboration, judges at 2016’s PPMA Industry Awards recognised MCS, Festo and Siemens with two awards, for Most Innovative Automation System and for Partnership of the Year, citing the innovation, flexibility and impact MCS provides for machine builders.

People
While the benefits that investing in Industry 4.0-ready plant can deliver should not be underestimated, it is also important to understand that in order to unlock and maximise the potential productivity gains and return on this investment, it is critical to focus too on people, helping them understand, prepare for and address the challenges they will face. This begins with leadership: success will depend on managing and leading the organisation through substantial and sustained change, where the accelerating pace and rate of change across both technology and process may contribute to increased levels of stress for employees. Business leaders must be mindful of this and begin by defining and articulating a compelling vision of the future for their teams that engages and galvanises the entire workforce – because the true value of Industry 4.0 can only be realised if it is fully embraced by shop-floor workers.

The role of people in the successful digitalisation of manufacturing will be absolutely critical. Human operators will remain the key element of modern production, but can expect to be...
assigned more and more new tasks. Employees on production lines will be required to step up and perform complex decision making, enact swift troubleshooting and oversee effective preventative maintenance strategies. Traditional ‘maintenance engineers’ may transition into ‘reliability engineers’, for instance, focused on maximising uptime, rather than resolving downtime. This will create an opportunity for traditional, higher labour cost regions to remain globally competitive, able to address high value manufacturing and increasing demand for ‘customisation’. That is an exciting possibility for countries, such as the UK, which have traditionally struggled to compete with emerging nations on cost alone, and is reflected in the increasing trend towards on- or re-shoring.

If Industry 4.0 is to deliver smarter machines and factories, it will require both leadership and vision, as well as an army of knowledgeable staff – this is not helped by either the skills gap or a looming leadership vacuum. As the workforce ages, a potentially cavernous gap is opening up behind experienced leaders and skilled workers, exacerbated by industry growth and change, as well as skills shortages. Potential solutions might include re-training and upskilling existing staff, as automation impacts processes, or helping workers from other sectors migrate and re-train.

Food and drink manufacturers and processors should also ensure they make the most of the forthcoming apprenticeship levy, which aims to fund three million apprenticeships in the UK by 2020. Coming into force in 2017 for employers with an annual payroll in excess of £3m, it will require these employers to pay 0.5% of their wages bill into the levy each month, with additional government funding also topping up the amounts. However, in return, firms will be able to access funds from the levy to help them plan and deliver their own apprenticeship training schemes.

**Training**

As the role of employees within the modern production environment transitions from that of simple machinery operator to highly skilled and quick-thinking problem-solver, new levels of training and knowledge will be fundamental. Education will become a key success factor in delivering smarter industrial environments. For workforces to fully embrace the opportunities offered by increased digitalisation, performing new and different tasks, such as working alongside collaborative robots, they have to understand what it means and know how to make best use of it. Training programmes, such as Festo’s ‘Qualification 4.0’ approach, will be increasingly important in addressing the industry’s change management needs.

**Leadership**

It will be essential for successful business leaders to continuously improve and develop their own leadership and change management competencies, creating an ongoing long term plan to proactively manage the change programme within their organisations. This transition will be critical in fully realising the value and productivity gains promised by Industry 4.0-enabled better plant in the UK food and drink manufacturing sector but will also help enhance and transform tomorrow’s production roles and environments for its people.

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**Festo**

As a leading industrial automation provider with a strong focus on the food and drink industry, Festo helps its customers to improve the digitalisation of manufacturing through its industrial automation solutions, as well as its training, development and consulting services. Festo offers a comprehensive, modular training system for Industry 4.0 and smart factories, the Cyber-Physical Factory, to help organisations and their workers successfully make the transition.

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Food manufacturers are continually exploring ways of improving processing throughput to meet increasing demand for food in a highly competitive industry. Automated processes are often preferred to manual ones, not only as a means of improving speed and reducing costs, but also to protect the environment in which food is picked, packed and dispatched to retailers.

In some food storage environments, which are unsuitable for humans to occupy for long periods of time, for example sub-zero freezer warehouses, automated solutions are necessary to ensure that operations can continue without interruption. Historically, the processing and production of food items has been conducted by people. However, process interruption can be caused by sickness, holidays and other human needs. The introduction of an automated cell for process implementation can increase reliability and speed leading to improved productivity. It can also enhance cleanliness and hygiene. In addition, the engagement of fewer employees in manual tasks mitigates a company’s exposure to Health and Safety issues, such as injury or Repetitive Strain Injury (RSI) claims.

Automated cells are better able to manage repetitive processes and can be programmed to continuously repeat a task with high dexterity, if necessary around the clock. This can offer cost savings to the manufacturer and eliminate the high expense of multiple shifts, ensuring production output is maintained.

Automated robots
Automated robotic manufacturers have been developing solutions for the food industry, however there is not a ‘one key fits all’ solution. There is a need for processes to become fully automated with high speed throughput, from upstream processing to end of line palletisation. Moreover, the upsurge in demand for bespoke or artisan products means that production runs can be shorter and more diverse, leading to a manufacturing environment where change is a constant and the need for a truly connected factory – as characterised by the uptake of Industry 4.0 – becomes ever more pertinent.

Robots have typically been used in the food industry for the completion of heavy work and laborious logistical tasks, such as lifting, packing and palletising, but advancements in the automated robotics industry are redefining the production line. Costs can be reduced significantly and product output is increased through the adoption of automated systems that can work independently.

Systems designed to work in direct contact with food, using food compatible lubricants and stainless steel parts, can handle foodstuffs in environments with temperatures as low as -30 degrees. Solutions must be able to integrate with existing operations. Capabilities need to include a range of parameters, such as axis and reach, payload, repeatability, interaction, communication and vision.

Machine-vision systems
Vision and conveyor tracking – the interpretation of the production environment within the AI arena and the decisions that come thereafter – is relatively new to automated robotics and as a solution, although still in its infancy, is beginning to take off. There is a need for robotic vision within the food industry to support processes, such as packing, wrapping, sealing etc. KUKA has been developing algorithms for industrial gripping and manipulation and real-time decision-making, for example to identify parts or items on a conveyor belt. It has been focusing on object detection, tracking and vision-guided control methodologies.

The introduction of an automated cell for process implementation can increase reliability and speed leading to improved productivity.
optimising the motions of multiple robot arms has been a key focus at KUKA’s state of the art training facility in Wednesbury. The aim is to pick multiple objects off moving conveyors in minimum time. Software modules and communication drivers are also under development to control the latest intelligent industrial work assistant.

Exploration of robot hand-eye coordination and movement within the workplace combines gaze control with bi manual movement and, once developed, cells could occupy an established production line managing processes synonymous with a food packaging environment, operating 24 hours a day, seven days a week, meeting output demand and satisfying health and safety regulations.

One current project, ‘Automatic gaze controller for assisting robot manipulator movement in the workspace,’ is addressing the problem of gaze control for a bi-manual robot consisting of a 7 degrees-of-freedom pan-tilt vision system (robot head) and two KUKA LWR’s (light weight robots).

The control framework is comprised of two components:

1) an adaptive visual tracker that is capable of tracking an arbitrary object with unknown trajectory
2) an optimised visual control strategy capable of controlling all joint motions of a redundant head-neck mechanism in order to retain the tracked object at image centre.

The advantage of such a framework is that it does not require any prior knowledge of the object trajectory and can achieve optimal joint motions, i.e. it minimises the maximum joint motions needed to maintain constant gaze. An adaptive gain has been used with the controller in order to provide fast convergence of the task space error when gazing at an object with unpredictable trajectories. The framework has been validated in real-time under various operating conditions.

Automated machine-vision systems within the food industry will provide manufacturers with significant benefits: improving quality and product processing times, reducing waste and labour costs, high levels of consistency and speed.

Human/robot collaboration
Human/robot collaboration introduces an element of unreliability. Humans do not replicate tasks as accurately as robots, but a cell needs to be able to adapt to changes in its environment, such as an object not placed in the same position on a conveyor, a variance in timings and the angle of an object.

Object tracking in real-time is one of the major tasks being developed to control the robot’s trajectory automatically. There are algorithms to track different objects, but most of them require prior information about the objects, such as their geometric primitives, texture, model information etc. Such methods are limited to track only particular objects of interest and require active
tuning of process parameters to migrate them to other objects. To solve this problem, an adaptive tracker has been developed that is independent of local object features and can reliably track various objects present in ‘the scene’. The developed tracker has already been tested in different environments and results of tests have demonstrated the following properties:

1) Cell is capable of tracking multiple moving / stationary objects; current version can track 62 different objects simultaneously.
2) Real-time operation; average tracking time per frame is 1.2 milliseconds.
3) Easy to migrate – single click initialisation of objects.

**Colour vision analysis**

Many existing machine vision solutions in the food industry currently operate using grey scale imaging. Developments at KUKA mean that applications currently being refined will instead operate using colour vision analysis. This is an application that could be implemented in a production line consisting of multiple elements, especially in the case of simultaneous object tracking capabilities.

Human/robot collaboration object analysis in both real time and colour can also support quality control. When humans are involved in a process that includes repetitive and/or mundane tasks, the occasional error is likely to occur. The adaptation of grasp trajectories of the robotic arm and hand with respect to changing object poses essentially provides the robot with the ability to grasp dynamic moving novel objects that have no prior models, i.e. the robot does not know that it is there. The developments are based on the ‘learned generative grasp model’, which generates a set of possible grasp trajectories for a given unknown object. The object pose is estimated by an adaptive 3D pose tracker to transform grasp trajectories into a new object frame; the robot will identify a path in order to select or manipulate an object.

**Conclusions**

As consumer demand rises and manufacturers increasingly look at ways to reduce costs and remain competitive in a fierce market, the need for robots within the food industry is likely to increase. Today robots play an essential part in the performance of primary packaging tasks, while the developments currently taking place give rise to entirely new capabilities within the food industry: the ability to visualise, pick and place items in real time.

There has been a gradual uptake of automated solutions within the food industry. Advanced manufacturing techniques are going to be essential to the continual development of automated robotics within the industry. Manual operations will remain for certain products or processes, but speed and agility are key.

There is still a need for human intervention in the production, processing and packaging of food items. Current systems are not sufficiently advanced to identify poor quality food items, whether by texture or smell. Human senses are very good at identifying whether an item is unfit for consumption, as opposed to a cell that operates based on colour, value or size. The potential for developing such sensory intelligence may be further explored in the future.

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Katherine Johnson is a marketing professional supporting KUKA Robotics in the development of its communications strategy.

Dr Naresh Marturi has experience in developing control algorithms and techniques for a wide variety of robots ranging from nano-scale to large scale industrial robots. His major field of research relates to computer vision, where he is involved in developing object detection, tracking and vision-guided control methodologies. At KUKA, Naresh’s main role is to facilitate the transfer of knowledge and expertise in computer vision and robotics from academia to industry.
Robotic chef creates recipe for change

Jake Norman of OAL and Mark Swainson of the National Centre for Food Manufacturing at Lincoln University explain how a new robotic chef allows food to be produced more rapidly, efficiently and hygienically with less waste and greater precision.

Robots cannot be considered ‘new’, but over the next 5 years they have the potential to significantly change how food is manufactured. To date, UK food manufacturing, whilst arguably the most advanced food sector in the world, has been slow to embrace robotic technologies. UK food businesses currently purchase approximately 60 robots a year[^1], predominantly to case and palletise end products. To put this number in perspective, China, often cited for its manufacturing prowess due to ‘abundant, cheap labour’, is set to buy 150,000 robots across all sectors in 2018[^2].

The manufacturing ‘efficiency and control’ game is changing and the UK sector needs to move fast to catch up. Robots have the potential to deliver better value and safer, more sustainable food.

OAL (Olympus Automation) and the University of Lincoln, National Centre for Food Manufacturing, have developed a new a robotic chef known as APRIL (Automated Processing Robotic Ingredient Loading). Demonstrations of APRIL are taking place at the National Centre for Food Manufacturing to allow food manufacturers to evaluate the technology for their own specific production processes. It can be daunting for a manufacturer to start this disruptive change process and the first step is education.

Food manufacturers face rising costs driven by the national living wage and change is needed to deliver long term growth and profitability. As a result, businesses considering the development of a new food factory should consider using robots to play a central role in the manufacturing processes.

Features of APRIL Robotic Chef

APRIL allows food manufacturers to move a cooking vessel from one processing/ingredient station (heat, mix, etc.) to another on an industrial scale. It is a very simple idea but the freedom to move is very powerful and is not possible in a traditional kettle gantry arrangement. APRIL offers the opportunity to automate both the handling of raw materials and processing at the same time.

Simon Lushey, Specialist Food Technical Manager at Marks & Spencer, believes that modular robotics cells may be able to transform food manufacturing kitchens, by breaking up processes in a different way, providing a step

[^1]: 60 robots a year
[^2]: 150,000 robots across all sectors in 2018

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change in performance. The trigger for their introduction will be the ability to improve taste, consistency, quality and value of consumer products.

Where can APRIL be applied?
To maximise the benefits of robotics, APRIL is best suited to new build factories. The first APRIL system is due to be operational in Europe within a year, manufacturing ambient sauces. The robotic manufacturing cell is particularly designed for batch cooking applications, which are typically utilised in producing a wide range of ‘ambient’, ‘cold-blend’, ‘cook-chill’ and ‘cook-chill-freeze’ products for retail, foodservice and B2B (Business to Business).

The APRIL system can incorporate OAL’s Steam Infusion heating and mixing technology that was researched and developed with the University of Lincoln under a £1 million Innovate UK project. Steam Infusion is widely used across the UK ready meal market, which includes chilled and frozen ready meals, pizza, sauces, soup, condiments and cook-in sauces. By incorporating Steam Infusion into a robotic manufacturing cell, the traditional bottlenecks of ingredient loading and cleaning are removed.

With UK ready meals set to grow by an average of 3.2% annually over the next four years to reach approximately £5.78bn in 2020 [3], there will be demand for increased production capacity. It has been suggested that new product development coupled with new process development is vital for achieving such growth forecasts. APRIL has potential to help manufacturers meet consumers’ growing demand for premium, healthy and natural products.

OAL has modelled a number of applications for APRIL, which will be further developed via research work with specialists in robotics, engineering and food processing systems at the National Centre for Food Manufacturing. The following application areas may be of particular importance.

Product consistency
Traditional soup, sauce and other liquid-based product manufacturing typically utilises large fixed cooking kettles (500 to 3000kg) requiring pumped and manual handling transfer systems for moving ingredients and finished product from one process step to another. This can lead to prolonged manufacturing times, variable product quality, much waste and high energy usage.

APRIL incorporates a semi-autonomous system that combines state of the art cooking and materials handling technologies with automated robotic ingredient loading, currently using vessels between 50kg and 750kg. The integrated system has been developed to produce higher quality food with improved flexibility and offers increased process consistency at a faster rate. Steam Infusion is widely used across the UK ready meal market, which includes chilled and frozen ready meals, pizza, sauces, soup, condiments and cook-in sauces. By incorporating Steam Infusion into a robotic manufacturing cell, the traditional bottlenecks of ingredient loading and cleaning are removed.

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downtime is incurred whilst the gantry and pipework are cut and reconfigured to make space for a new device needed to cook the latest soup innovation.

APRIL systems can eliminate gantries and fixed pipework making the addition of new modules easy. A new ‘cook’ module can be designed, manufactured and tested off site before being placed into the robotic cell. The module is then added to the software sequence and hooked up to services with minimal downtime.

**Extended shelf life**

Processing food using APRIL has the potential to be more hygienic than ‘traditional’ methods enhancing food quality and freshness. The lack of human interaction with products and the consistent, predictable and accurate execution of tasks will help reduce ‘contamination incidents’ and related product recalls (e.g. due to undeclared allergens or accidental addition of foreign bodies to the product due to operator error).

As APRIL can work autonomously, manufacturers can place the system in a sterilised area and/or an optimised atmosphere selected to extend the shelf life of products and reduce food waste.

**Lights out manufacturing**

At the start of the robotic batch manufacturing process a works order will be fully digitised from its source, which could be a digital works order from an ERP (Enterprise Resource Planning) or a paper works order. The digitally formatted works order will then trigger a series of technological scheduling and manufacturing actions. This approach has the benefit of being able to check and optimise the processes required for every unique ‘production occasion’ and ultimately has the potential for ‘lights out’ manufacturing (running autonomously with no human interaction).

Such advanced processes will form part of the ‘farm to fork’ supply chain as products physically and digitally cross industry sectors. In short, utilising principles from Industry 4.0, the order will first be simulated, running a vast number of production scenarios before settling on the best option for that specific point in time; ultimately optimising and enabling ‘right-first-time’ manufacturing.

It is envisaged that this manufacturing approach could be linked into suppliers’ systems to develop a ‘just in time’ delivery process as employed in many other manufacturing industries (e.g. automotive and aerospace), thus reducing storage and waste costs.

**Safer operating environment**

The autonomous APRIL manufacturing platform can also protect operators from the harmful effects of some ingredients and the physical challenges of manual handling, freeing them to do other more productive duties within the factory, thus improving the working environment and health for all involved.

**Next steps**

Food manufacturers can learn more about APRIL technology at the National Centre for Food Manufacturing, where OAL and the University of Lincoln are committed to:

- Providing education on the opportunities for automation and robotics.
- Partnering with and supporting visionary ‘early adopters’.
- Working to develop and deliver disruptive change in food manufacturing.

References and article available online at: [www.fstjournal.org/features/31-1/robotic-chef](http://www.fstjournal.org/features/31-1/robotic-chef)

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Last year a conference at the National Centre for Food Manufacturing brought together food industry leaders and technologists to discuss the future of food production. There will be another ‘Food Manufacturing 2030’ event in September 2017, register your interest at: [http://www.oalgroup.com/food-manufacturing-2030-conference/](http://www.oalgroup.com/food-manufacturing-2030-conference/).
Challenges
The food and drink manufacturing industry is the largest manufacturing sector in the UK, employing approximately 400,000 people. The gross value added to the economy is £21.9 billion and accounts for almost 16% of total manufacturing turnover in the UK. It is evident that the food and drink industry to the UK and is critical in shaping how food is produced and consumed, which ultimately contributes greatly to the health and wellbeing of the population.

However, there are huge pressures facing the global food system, from farm gate to the consumer and beyond. The challenges of meeting the demands of the growing population, responding to shifting consumption habits and behaviours and tackling epidemic health issues, whilst monitoring environmental impact, will require improved utilisation of limited resources. New science and innovation is vital to develop resilient food systems which, whilst minimising waste, provide long-term, sustainable solutions for food production to supply safe, nutritious food. The EPSRC Centre of Innovative Manufacturing (CIM) in Food was established in December 2013 to address some of these challenges.

Manufacturing expertise
The aim of the EPSRC CIM in Food is to meet the challenges of global food security through developing world-class technologies, tools and leaders. This is tailored to meet the needs of current challenges while redesigning resource-efficient and sustainable, nutritious foods of the future. The £5.6 million Centre is a collaborative venture between the University of Nottingham, the University of Birmingham and Loughborough University. The University of Birmingham’s Centre for Formulation Engineering meets the process needs of industry in the manufacture of micro-structured materials. Loughborough University has a strong focus on sustainable manufacturing and leads in areas, such as sustainable product design, low carbon manufacturing and supply chain management.

The University of Nottingham’s Department of Food Science has a focus on biomaterial processing and has a bespoke food processing facility. Drawing on the strengths of each institution, the centre is well-equipped to tackle food and drink manufacturing issues. With eight academics and over 30 researchers, the Centre has brought together expertise in biomaterial science, formulation engineering and sustainable manufacturing.

The Centre has two overarching challenges: ‘sustainable food supply and manufacture’ and ‘innovative materials, products and processes’. These challenges are broken-down into six research themes, which the centre is focused on:

• Sustainable food supply chain
• Eco-food manufacturing
• New flexible manufacturing processes
• Upgrading ingredients
• Food manufacturing for healthy diets and lifestyles
• Processing technologies

To date, the Centre has over 50 national and international industrial and academic collaborations and has secured over £6.4 million of government and industrial funding. Industrial partners include 2 Sisters Food Group, AB Sugar, Bioscience KTN, Cargill, FDF, McCain Foods (GB), Manufacturing Technology Centre (MTC), Marks & Spencer, Mars, Nestle, Pepsico, Premier Foods, J Sainsbury and Unilever. By actively engaging with other institutes, networks and food and drink manufacturers, the EPSRC CIM in Food undertakes innovative research that translates effectively into technologies for...
the industry that are aligned with consumer needs.

**Current research**

A better understanding of the interplay between food components and processes is needed to sustainably engineer foods that are fit for purpose. For example, determining how extraction conditions relate to the quality of oleosomes will allow us to identify how these naturally emulsified structures may be applied to food formulations. To design better processes, a fundamental understanding of foam and emulsion formation will enable the design of stable food structures using sustainable solutions that are far less energy intensive.

The food sector needs to take into consideration its environmental impact in manufacturing and must not continue producing at the expense of the environment. An approach to reducing environmental impact is for manufacturers to consider the product design and process of manufacturing as a way of developing resilient supply chains. The Centre is partnering with industry to test these methodologies for factory implementation. Another way to address environmental impact is to categorise and examine the factors contributing to food waste from production to end-product use. These are some of the projects that are being explored at the Centre to aid the reduction and improved utilisation of food waste. The large volumes of effluent generated by the food manufacturing sector represent a significant disposal cost. Researchers have developed a non-invasive sensor which provides feedback on effluent to optimise treatment of water. Another focus of the Centre is the feasibility of food production in relation to distribution chains and how food materials and manufacturing processes can be developed that are more resilient to change. Researchers at the Centre are developing a set of metrics to highlight areas where distributed and localised manufacturing may provide economic, environmental and social benefits. Other research has focused on formulation and processing techniques that are relevant to the food sector. The team is developing new food formulations that can be dried for prolonged shelf life and rehydrated when required to achieve desirable organoleptic properties.

The Centre is also exploring different methods of using edible materials for additive manufacturing. CIM researchers are exploring Fused Deposition Modelling to process food grade... More online
Case Study 2: Drying and rehydrating for distributed manufacturing

There are increasing demands for food manufacturers to deliver quality products free-from preservatives to consumers. Drying is used extensively in the food industry to prolong the product shelf life by inhibiting the growth of microorganisms and their enzyme activity without the use of preservatives. Some of the most commonly used drying techniques are oven drying and freeze drying. However, these methods can often have detrimental effects on the texture and rehydration capacity of the dried food. This is particularly apparent in fruit and vegetables, which have a high moisture content. The other major drawbacks are the very long processing times and high energy costs. Osmotic dehydration could be an effective pre-treatment for these drying processes. Foodstuffs are dehydrated by immersing them in a hypertonic solution where moisture diffuses from the food towards the solution.

Researchers at the Centre have shown that by using an osmotic dehydration pre-treatment, drying times of strawberries for both oven and freeze drying can be greatly reduced. The mechanical and structural properties of the strawberries were also better retained. From an industrial point of view this could lead to a reduction in cost and improvement in the quality of the product.

Case Study 3: Upgrading food waste for emulsion stabilisation

Pickering particles are solid particles that are adsorbed at the oil/water interface to stabilise emulsions. They can be used to replace artificial surfactants and offer stability and prolonged shelf-life. However, most of these Pickering particles require chemical modification and are often restricted in food application. Previous work at the Centre has demonstrated that natural Pickering particles, which are suitable for food application, have emulsifying properties in part due to lignin.

Based on this finding, research was conducted to utilise the hydrophobic nature of lignin to design Pickering particles to stabilise food emulsions. Ground coffee waste was selected due to the natural presence of lignin in cell wall material, the current acceptance of coffee in food and beverages and the generation of large quantities of coffee waste globally. In Europe alone, manufacturing instant coffee produces approximately 300,000 tonnes of spent coffee waste annually, in addition to 550,000 tonnes of ground coffee waste a year from UK coffee shops and households. The research has demonstrated that waste coffee particles can act as Pickering particles for oil-in-water emulsions and water-in-oil emulsions. The emulsions were stable over a wide range of pH, shear and temperature conditions. This research has established that lignin-rich food waste can be upgraded to functional food ingredients that are capable of stabilising emulsions.[2]

This work has led to follow-on funding for two PhD projects investigating alternative thermal processing and extraction protocols to create a range of natural lignin-rich particles for food formulations.

References and article available online at:
www.fstjournal.org/features/31-1/innovative-manufacturing

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Open Innovation in food production

Dominic Oughton of the Institute for Manufacturing at the University of Cambridge describes the crucial role played by Open Innovation in delivering value to both large corporations and innovative start-ups in the food and drink sector.

What is Open Innovation?
Open Innovation (OI) is an approach whereby organisations seek to collaborate with others to deliver innovation. Innovation is often a collaborative activity but the practice really came to the attention of industrialists and academics alike when Henry Chesbrough coined the phrase ‘Open Innovation’ in 2003, defining it as ‘the purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively’[1].

OI is typically depicted as adding a ‘permeable boundary’ between the organisation and the external environment, with flows of information and knowledge into and out of the ‘innovation funnel’, as ideas are developed into products and services that are taken to market [Figure 1]. This embraces many different types of interaction, from adoption of blue-skies research through licensing of mature Intellectual Property (IP) to co-branding of mature products and spin-out of under-utilised technologies. Underlying this philosophy is a core belief that ‘we don’t have a monopoly on good ideas or the best brains in this organisation.’

OI in food and drink
OI has been widely adopted across many industrial sectors, with fast-moving consumer goods (FMCG), pharma and computing in the vanguard, and ‘faster’, ‘better’ and ‘cheaper’ all being cited as benefits. Larger companies need access to new ideas and technologies to feed their innovation processes. They need to source them from wherever they are generated. This is particularly true for firms competing in the food sector where tens of thousands of new food and household products are introduced each year to serve niche markets across the globe. The variety of products is likely to grow further as firms increasingly aim to serve the individual consumer’s needs.

Bringing together small and large companies in mutually beneficial partnerships seems the obvious way forward; harnessing the speed, entrepreneurship and innovative capacity of small firms to feed the channels, brands and resources of the large company should create the new value for consumers that neither firm could deliver alone.

Specifically in the food and, more generically, FMCG sectors, major corporations have embraced OI models consciously and, with encouragement from top managers, they are implementing and coordinating OI through dedicated teams. As Mortara et al. [2] found in one of their case studies, this sector recognises the potential power of OI: ‘the “outperformers” in the food industry use external sources of innovation.’ OI seems a successful approach to achieving sustained high growth and containing innovation costs. Furthermore, FMGC’s innovation is strongly dominated by brands and the adoption of OI contributes to the reinforcement of branding messages.

Today a number of drivers are encouraging an environment where entrepreneurial start-ups can deliver vital innovation. These include:
• the rise of the demand for organic and sustainable products,
• the need to respond to issues like obesity, diabetes and allergies in...
the population,
• the discovery and demand for ethnic foods by the mainstream.

Amongst the highest profile adopters of OI is Procter & Gamble (P&G), with former CEO, AG Lafley, inspiring a culture change from ‘not invented here’ to ‘proudly invented elsewhere.’ P&G’s Connect & Develop (C&D) programme has been highly successful, producing more than 35% of the company’s innovations, including Pringle Prints, and billions of dollars of revenue.

Another example of the application of OI in the food sector is International Flavors and Fragrances. IFF taps into the creative potential of its customers when conceptualising and designing products. Using an internet toolkit with a large database of flavours, the company involves the customer when creating a new flavour. Co-creation allows it to increase its ability to meet individual customer expectations and to reduce time-to-market.

Challenges for large corporations
The challenges faced by organisations in adopting Open Innovation vary depending on which end of the ‘collaboration telescope’ they are looking though; global corporations and nimble start-ups see things very differently.

Large corporations face both ‘hard’ and ‘soft’ challenges in moving to a more open approach, needing to re-think many of their business processes to adopt, for example, the ‘Want-Find-Get-Manage’ framework developed by Gene Slowinski – perhaps the most widely used framework for OI. They may also need to rebalance their innovation resources and infrastructure. However, research suggests that simply rewiring the ‘innovation hardware’ without consideration of soft factors around motivation, skills, culture

and metrics is unlikely to yield results. Chief amongst the factors behind successful OI programmes is clear leadership from the top of the organisation; it is essential to overcome the ‘not invented here’ syndrome, which is the natural legacy of a traditionally self-contained or closed approach. However, slogans and rhetoric are not enough to change behaviour. Rewards systems need to be revisited, perhaps giving equal recognition to the colleague who scouts a new partner as the one who publishes a patent. Incentives and culture change need to be backed up with additional skills in collaboration, negotiation and intellectual property (IP) to complement existing technical skills. Importantly, those who will be in the front-line in developing and cementing these new external relationships need an empathetic and outward-looking mindset.

Food start-ups, on the other hand, face very different challenges in the OI context. Two of the primary obstacles they need to overcome are the entrenched nature of food distribution channels and systems and a lack of seasoned entrepreneurs in this segment of the industry. Clearly, leveraging the resources of large, established players can help them address both of these issues.

Challenges for innovators
For the innovation provider, often a small or early-stage company or perhaps a university department or spin-out, the challenges of embracing OI are different but no less great. Many of these derive from the fundamental asymmetry of the ‘elephant and mouse’ nature of a partnership. Some of the most pressing issues are described below.

How and with whom to engage
The complexity and scale of large company operations mean that even their own staff are sometimes unable to help a start-up contact the right people - finding the right entry-point is the first of many challenges faced by the early-stage firm. This is compounded by understanding the different roles of people in a large company. Who is the decision maker? Who influences them? Who will be working on implementing the partnership? Who will be affected by its outcome? Moreover, as soon as a contact point is established and developed there is every likelihood of them being moved along by the ‘big company merry-go-round’.

Different ‘clock speeds’ and power imbalance between partners
Small start-ups are usually able to make decisions very quickly. Large firms, due to their complexity and multiple layers of management, often find it very hard to make decisions at ‘start-up speed’. This can be very frustrating for the start-up – undermining the very trait of agility that the large company was hoping to achieve through partnering: getting to innovation ‘faster’. Such relationships may have a very different context in the two organisations. For the large company, this may be just one of many technology positions within a portfolio. For the start-up, the partnership with a large company is likely to be a survival issue. This can push the cash-strapped start-up towards accepting less lucrative deals or simply serves to undermine confidence in the partnership.

So many of the strategic issues and opportunities in the food, drink and FMCG sectors need a joined-up approach to make real progress; sustainability, provenance and obesity cannot be tackled through bi-party relationships alone. One great example of such cross-industry collaboration is INCPEN, whose members are an influential group of international and British companies with a common interest in packaging.
Experiences from the IfM’s Open Innovation Forum

The IfM’s Open Innovation Forum also takes a cross-sector approach, bringing together some of the key players to share best practice in OI and to explore ‘hot topics’ along the food and FMCG value streams. The recent OI Forum ‘Pitching Event’ gives an interesting insight into the challenges and opportunities that companies in the food and beverage sector are looking to address through OI. The IfM worked with the twenty member companies to establish their highest-priority innovation needs and then took the consolidated ‘Top 50’ to innovators from universities, start-ups and SMEs, looking for solutions.

Eighteen finalists were shortlisted to pitch their innovations to the OI Forum ‘dragons’; the winners highlighted both the breadth of the challenge and the types of organisation that are able to respond to this approach.

The overall winner was Nuritas Ltd, an Irish bioinformatics technology company specialising in the discovery of peptides (chains of amino acids) with disease beating properties. The company’s disruptive computational approach to discovery uses artificial intelligence and DNA analysis, which provide unique solutions for the maintenance of health and wellness in industries, such as functional and medical foods, pharma and cosmetics. This is a great example of transferring non-traditional technologies (big data and AI) into the sector to deliver a critical innovation need [improved health and wellness].

Amongst the ‘Highly Commended’ companies was Senseye Ltd, a peer-to-peer service that enables farmers in the developing world to share information via SMS, without the internet and without having to leave their farms. Small-scale farmers are highly vulnerable to the effects of climate change and face many other challenges, including lack of access to traditional markets, agricultural inputs and finance. Every day, individual farmers develop a diverse range of innovative, low-cost solutions in response to these challenges. Senseye’s service enables these solutions to be shared and leveraged by other farmers demonstrating a truly dispersed OI model, addressing the challenge of sustainable food for a growing population.

Another Highly Commended entrant was Senseye Ltd, a start-up offering automated diagnostics, prognostics and condition monitoring to help eliminate machine reliability problems by revealing what is happening now and predicting what will happen in the future [6]. This is another good example of a novel technology solution to a ubiquitous challenge for all sectors, including food and drink: how to derive higher Overall Equipment Efficiency (OEE) from existing investments.

The ‘Pitching Event’ is an interesting adaption of the first two stages of the Want-Find-Get-Manage model:
• identifying what resources are Wanted,
• Finding potential external sources,
• Getting access to these resources,
• Managing the relationship.

It will be up to the ‘dragons’ and ‘pitchers’ to navigate the last two stages, striking a deal and delivering value from it for all concerned.

Conclusions

Collaboration, and specifically an Open Innovation approach, plays a crucial role in delivering value to the food and drink industry and addressing some of the broader societal challenges, such as sustainability, food security, provenance and health. External sources of innovation, from start-ups and universities or from outside the sector, can be harnessed to great effect in delivering value, whether measured in commercial or societal terms. Navigating all the challenges and potential pitfalls identified above requires that this value is shared equitably and success is most likely to be underpinned by people with an ‘open’ mindset.
Designed to help SMEs in the food sector innovate and grow, the Food Innovation Network (FIN) is a new, national initiative for small and medium-sized food businesses (SMEs) to give them greater access to world-leading technology. It is part of the Government’s 25-year plan to position the UK as a global leader in food and farming. The FIN’s primary objective is to tackle the issues currently impeding innovation, productivity and growth in UK agri-food and drink businesses. The FIN is co-funded with two other bodies: the York, North Yorkshire and East Riding Local Enterprise Partnership and the Biotechnology and Biological Sciences Research Council. It will be co-ordinated by the Knowledge Transfer Network (KTN), which will help to champion and establish the FIN with industry and shape its work programme, as well as engage extensively with industry, academia, funders, innovation enablers and users.

**Launch**

More than 200 people were at the National AgriFood Innovation Campus in York in October 2016 to witness Andrea Leadsom, Secretary of State for Environment, Food and Rural Affairs, launch the FIN. With almost 40 exhibition stands representing agrifood sectors, such as education, research, regional food and trade associations, the launch day was a superb opportunity to network and begin to understand how the FIN will connect people. Environment Secretary, Andrea Leadsom, said: ‘Our thriving food and drink sector has already helped make Britain more globally competitive through its incredible innovation. The UK’s food and farming sector generates over £100bn a year and employs one in eight people, with the food-manufacturing sector bigger than cars and aerospace combined.’ From extending the shelf life of our food to increasing the amount of Vitamin D in our eggs, the Food Innovation Network will help make the sector as forward-looking as possible and push the boundaries of British food production.’

Opening remarks came from Ian Noble, Senior R&D Director at Mondelez and Chair of the Food Innovation Network, and throughout the day, there were presentations from successful innovators and AgriFood support services.

Tim Finnigan of Marlow Foods described how Quorn products are continuing to grow the consumption of plant-based food with research into improved flavours and textures. The Intellectual Property Office launched its new Lambert Toolkit to assist academic or research institutions and industrial partners looking to collaborate on research projects.

**Lambert Toolkit**

The Lambert toolkit was created to assist academic or research institutions and industrial partners wishing to collaborate on research projects. The objectives are to:

- facilitate negotiations between potential partners
- reduce the time, money and effort required to secure agreement
- provide examples of best practice.

The toolkit consists of:

- a decision guide
- 7 model research collaboration (one to one) agreements (1-6)
- 4 consortium (multi-party) agreements (A-D)
- heads of terms and variation agreements for both collaboration and consortium agreements
- guidance notes

The model agreements are not sector specific and can be adapted to meet the particular circumstances of a project or collaboration.
wishing to carry out research projects together. This was organised by the AgriFood Tech Council to support the translation of UK academic excellence into commercial success, with minimal delays over IP agreements.

Attracting SMEs
SME engagement is a well-known challenge, so the FIN will pilot differing approaches, such as breakfast meetings, evening meetings, competitions (funding permitting), online surveys via social media channels, specialist workshops (IP, winning funding, reward crowd funding, etc.) and thought leadership articles in the York area. The York, North Yorkshire and East Riding region is an ideal location to be at the heart of this initiative, as it has world-class business, internationally renowned assets and industry.

Web portal
As the FIN progresses, there will be other examples of how barriers to innovation will be lowered or removed. For instance, the FIN will be developing a web portal that will allow users to find collaborators, facilities, funders, experts and interact with each other to speed up innovation. Key to this will be the KTN AgriFood UK landscape portal – an overview of industry activity across the country – and konfer [2] (see FS&T, September 2016, p41), a tool being developed by the National Centre for Universities and Business (NCUB).

What’s next?
2017 is going to be a big year for the FIN with a number of challenges, such as:
• Making sure that small and medium size food businesses know that the FIN is there to help them
• Listening to industry needs and developing answers and solutions where possible, using the AgriFood Tech Council to influence Government where appropriate
• Identifying how best to turn BBSRC-funded research into commercial opportunities
• Being a focal point for existing groups within the York, North Yorkshire and East Riding region, thus making them stronger together
• Learning from pilot successes in the York, North Yorkshire and East Riding region and using them to engage in other regions.

konfer
konfer is a new tool for enhancing university-industry collaboration created by the National Centre for Universities and Business (NCUB), working in partnership with the Higher Education Funding Council for England (HEFCE) and Research Councils UK (RCUK).

When a business owner spots an opportunity, konfer supports the journey from finding a research partner and funding to planning and co-creation. It does this by providing direct access to:
• 8000 academics
• 11,000 facility and equipment listings
• 800,000 web pages from university sites and social media
• 22,000 YouTube videos from university channels
• 10,000 news, funding and events articles from curated feeds
• 50,000 publicly funded research projects

konfer brings knowledge and growth to businesses, valuable exposure for university talent and future strength for the UK economy.

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References and article available online at: www.fstjournal.org/features/31-1/food-innovation-network
Supply chain risk management maturity model

From a large food business perspective, it is easy to overlook the fact that the industry has a vast number of small and micro businesses, many of which have no supply chain risk management system in place. Food businesses can be divided into the following groups according to the extent to which they are addressing supply chain risks:

- **No risk management systems in place**—often single multitasking owner manager with no employees.
- **Basic systems are present, but not working to any standard.** Typically sourcing all ingredients from established distributors and relying on the distributors’ supplier assurance systems. This works well where businesses are sourcing from reputable distributors with robust supplier assurance but fails when distributors are less reputable.
- **Working to standards, such as GFSI and BRC, but struggling to consistently comply; are frequent recipients of major non-conformances.**
- **Doing enough to have minimal non-conformance on audits, but coming under pressure as the robustness of audits increases in a supplier assurance system.**
- **Companies with no audit non-conformances as a result of investment in supply chain risk management systems, such as QADEX.** Companies at this level are constantly challenging and improving their processes. Audits are still a stressful process and there is a sense of relief when an audit goes well.
- **Well embedded food safety cultures with systems operating at an excellent level. Audits are not a source of anxiety but are viewed as frequent validation that systems are operating to high standards. Audit non-conformances, where they arise, are a source of intense debate between auditor and auditee and will often revolve around interpretation of a requirement rather than a fundamental shortcoming in food safety systems.**

The most advanced food businesses will actively engage with modelling of emerging threats to stay ahead of risks.

**Emerging threats**

Every food and drink business has a unique supply chain and the emerging threats facing a supply chain will vary from business to business. Threats can be classified as:

- Risks initiated by individual or organised human factors, such as economically motivated adulteration (EMA) and substitution, bioterrorism, cyberterrorism and acts initiated by disgruntled employees or external parties.
- Diseases, such as animal disease, pandemics and antibiotic resistance.
- Global challenges, such as political, economic, social and technological (PEST) risks.
- Global challenges, such as sustainability, ethical and global warming.
- Food safety risks
- Marketplace risks due to supply and demand imbalances.

Economically motivated adulteration and substitution has been widely publicised since the 2013 horsemeat scandal. The University of Portsmouth has forecast that the extent of food fraud in the UK alone could be as much as £11bn per annum. The industry is very good at responding to the most recent incident and has invested vast sums introducing vulnerability assessments to identify EMA risks requiring mitigation, but...
this has reduced its focus on other emerging risks. Following the 9/11 attacks, there was an increased focus on bioterrorism risks, but in recent years the food industry has been distracted by EMA. However, bioterrorism is still a risk that needs to be considered. Recently, the threat of cyber-terrorism has grown but many businesses are not prepared for how this could impact on their supply chain. Addressing the consequences of the following situations may help to identify some of the impacts of a cyber terrorism attack:
- Inability to use IT systems
- Inability of suppliers to use their IT systems
- Shutting down of one or more of the major utility networks
- Unavailability of the internet for an extended period
- Telephone and communication systems unavailable.

Risks may be posed by a disgruntled employee or member of the public. Many will remember the story of Paul Bentley, the disgruntled Pork Farms employee who spread nuts around a nut-free area within the factory resulting in a disruption reported to have cost £1m. Companies need to consider the impact that a disgruntled employee could have on the business by identifying which actions could cause the maximum disruption.

**Disease related risks**

As the world has become more interconnected with rapid movement of people, livestock and goods, exposure to major animal diseases and Zoonoses has increased. Global efforts to co-ordinate risk assessment, communication and collaboration are led by the World Health Organisation.

A pandemic is an epidemic of infectious disease that spreads quickly through the human population across many continents. In recent years, the most likely pandemic risk has been the H5N1 strain of Avian Flu, which has been contained to date. In December 2016, the World Health Organisation.

...
### Challenge | Issues
--- | ---
Information silos | Different teams using different IT systems responsible for different facets of supplier and product approval, ethical, sustainability, product quality and consumer care.
Requirements of standards | Quality management systems historically set-up to comply with food safety and customer standards to pass audits.
Uncooperative supply chains | Difficult to gather the data required from suppliers in a timely and cost effective manner.
Inconsistent auditing | A global challenge that certification bodies have been grappling with for years.
Inconsistent retailer standards | Standards not always consistent, causing problems for manufacturers who supply to many retailers.
Inconsistent approaches globally | International trade has added complication of different approaches in different regions.
Lack of Resources | Insufficient technical resource to identify all relevant threats.
Lack of knowledge | Lack of qualified scientists to replace those who are retiring or leaving the industry, reducing the industry knowledge base.
Lack of VACCP/TACCP experience | Lack of experience in completing vulnerability assessments for the BRC Food Standard Issue 7 (introduced in 2015).
Best practice still emerging | Best practice still emerging for vulnerability assessments and forecasting emerging threats to the supply chain.
Bias towards avoiding non-conformance | Primary focus of many food safety teams is on avoiding non-conformances to standards.
Too little data | Insufficient quantitative data for vulnerability assessments resulting in subjectivity.
Too much data | Vast amounts of data in paper based documents, email servers, spreadsheets, ERP and other software systems may be unconnected.
Subjectivity | Subjectivity in risk assessments for supplier assurance systems and evaluation of emerging threats leaves businesses open to challenge.
Requirements changing quickly | Sub-optimal activity in food safety teams as the focus changes with time.
Under investment in food safety | Food safety resources not increasing in line with increased workloads, resulting in resource being stretched.
Historical data sources | Historical data sources can be utilised as part of supplier assurance and forecasting emerging threats to a supply chain and some are available free of charge.
Internal data sources | Food safety questionnaires could be upgraded to fulfill many tasks, such as supplier risk assessment and approval, managing ethical compliance, sustainability and suppliers’ compliance with codes of practice, capturing data from suppliers to inform vulnerability assessments and to identify emerging threats.

### SUPPLY CHAIN THREATS

**Joined-up thinking**
Auditing suppliers is an invaluable tool in the supplier assurance toolbox. Too many food and drink businesses do not audit suppliers due to resource and budget constraints. However, auditing suppliers provides an opportunity to capture additional data, which can help identify emerging threats.

Raw material specifications are often handled by a different team to those responsible for supplier assurance and evaluating emerging threats to a supply chain. In practice, there is useful data within the specifications that could be further enhanced with carefully considered upgrades to specification requirements.

Goods-in checks and quality monitoring is often on an ad-hoc basis to confirm compliance with specification or as mitigation for an identified risk. These are often completed as a tick box exercise rather than capturing data points, which could be later analysed to pick up unusual patterns that might indicate a threat within the supply chain.

Consumer complaints are often seen as the responsibility of customer care teams unless a complaint requires investigation. Level 1 complaints, such as issues of taste and texture, are often only reported with trend reports without detailed data analysis.

Ethical and sustainability compliance data are often handled by different teams without close collaboration with supplier assurance. It is contended that excellent suppliers will perform well across the spectrum of food safety, ethical and sustainability, since these businesses are likely to have enlightened management.

Conversely, poor performance in any area could be an indicator of elevated risk in other areas, yet how many food businesses take this integrated approach to evaluating supply chain risks?

Collating and analysing internal data is time consuming and may require replacing manual and paper based systems with an integrated database. The emerging threats to a supply chain are likely to come from areas businesses are not already aware of and are therefore likely to be external to the business.

**External data sources**
Many food and drink businesses are members of research associations.
such as CampdenBRI or Leatherhead Food Research in the UK, which frequently publish updates and reports highlighting emerging risks that their experts have identified. Trade associations are another good source of intelligence, which is often category specific and tailored to the needs of their members.

The European Rapid Alert System for Food & Feed (RASFF) is a quick and effective tool for exchange of information between competent authorities when risks to human health are detected in the food and feed chain. It measures withholding, recalling, seizure and rejection of the products concerned. The United States has a similar system to RASFF, known as Foodshield, which food and drink businesses can access following registration.

In recent years, the internet and social media channels, such as Twitter and Facebook, have become useful tools in the identification and tracking of emerging issues. Google searches for any ingredient along with the term fraud are likely to find a range of articles. The internet and social media present a challenge in validating the credibility of sources and the likely recycling of articles across multiple outlets.

The internet is also an excellent source of data for general emerging PEST risks. A multi-disciplinary team and extensive time is required to research and collate the various risks that could impact on a supply chain. All the internal and external sources discussed so far, are based on historical data. The truly difficult question to answer is what can be done to predict the next sudan I/ acrylamide/dioxin/horsemeat crisis. Very few food businesses have the resources to accurately model and predict emerging threats. Similarly, it would be very difficult for external agencies, such as government, to take on this responsibility, as the scale and scope of the food system is just too diverse.

Nonetheless, approaches ranging from the near-term and practical to innovative, emerging technologies, can provide valuable insight.

**Predictive data sources**

RASFF is one of the most comprehensive datasets available in Europe but in most instances, it is not used proactively by food and drink businesses. However, in one study, Bayesian Modelling was used to predict 80% of the food frauds reported on RASFF.

TNO’s predictive solution, ERIS (Emerging Risk Identification Support), helps food and drink businesses globally to identify and evaluate existing and emerging food safety risks and respond effectively to them.

Social media is likely to play an increasing role in picking out ‘noise’ and ‘chatter’ around particular ingredient and commodities in the coming years but will require more sophisticated usage by the food and drink sector to analyse the vast streams of data. Algorithms and artificial intelligence are likely to emerge as valuable tools.

While humans begin to struggle with this amount of data, algorithms and artificial intelligence systems will be able to analyse it in real time and pick out patterns. These patterns will be clear signals for emerging threats.

**Making sense of data**

Well-established principles of risk assessment, referred to as ‘multi-dimensional’ or ‘360°’ risk assessment, are useful for data interpretation.

Product risk assessments can be broken down into sections, such as: micro, chemical, allergy, pesticide and vulnerability, based on business preferences. For multi-site businesses, these risk assessments can be completed at each site based on how the site processes each ingredient and the end product use.

From a group perspective, a ‘worst case’ scenario is taken and this governs whether the site introduces mitigation to manage the elevated risk or increases the supplier risk profile and audit frequency.

Supplier risk assessments need to be much more holistic than food safety risk assessments and to address the following issues as a minimum:

• Food Safety
• Commercial
• PEST
• Security
• Disease
• Sustainability
• Ethical

Separate variables should be scored in each section and the scoring system should be kept simple (low, medium, high) with quantitative variables used for scoring. Subjectivity is not recommended as users get confused and resultant risk assessments can be inconsistent. A useful filter to apply to risk assessments is a probability impact assessment.

Every risk has two characteristics: the probability that it might happen and the impact it would have if it did. These can be assessed on a scale, such as high, medium and low. The guideline for what constitutes high or low is not universal and will need to be configured to each business. The risks can be visually represented on a 3*3 or 5*5 matrix and RAG (red, amber, green) colour coding applied.

Having completed the probability impact assessment, it should be clear which risks require mitigation. Good luck!
Unlocking big data

George Steven of Nalanda Technology explains how new software technology can help food companies to tackle information overload and make better use of historical data to improve their performance.

Introduction
Data is continuously generated from smart phones, wearable technology and all the other devices that are connected with each other in the Internet of Things (IoT). This creates both structured and unstructured data from documents, spreadsheets, emails, web pages, images, text files, XML and database records. This explosion of new information continues to grow on a daily basis, with over 90% of all the data in today’s world having been produced since 2011. Now there is an ever-growing demand to produce and have access to new tools and solutions, which can deal effectively with this abundance of big data. With these big problems also comes new opportunities.

The evolution of big data analytics has been staggering; it has progressed from an underused asset to a vital source of intelligence and insight, driven by improved hardware, cloud technologies and a plethora of specialist software. These technological advances have pushed the boundaries of what is possible, driving innovation and enabling huge strides forward in fields like Artificial Intelligence (AI) and Cognitive Computing. There has been a marked acceleration of big data deployments, with businesses now utilising their data capabilities as a key source of competitive advantage. Regardless of the size of enterprise, big data is a valuable asset with companies focused on delivering tangible business outcomes.

New methods of data capture are becoming more commonplace in food manufacturing. With the IoT making its way steadily through the industry, more emphasis is being put on gathering and using data not only to better understand and service customers, but also to support more informed decision making.

Within the food manufacturing industry, the big data challenge has multiple dimensions as companies seek to:

• manufacture cost effective products that industry and consumers will buy
• stay competitive
• embrace new processes
• influence the future

In a sector that influences and is influenced by global economies, multinational distributors and independent retailers, staying ahead of the competition is more than important; it is essential!

Use of big data in the food industry
Customer intelligence
This is perhaps the most obvious use of big data. Data can be pulled from forums, social media, image sharing sites, customer review sites and so on, and used to gather real time details on competitor offerings and consumer preferences. This market intelligence can be invaluable for a company to gain competitive advantage and deliver what customers want. Learning from the past will help to look towards the future, so being able to gain insights into a company’s own products and procedures is only part of the challenge. Recognising how a competitor has been able to come to the market first with an innovation will help other companies to learn from the competitor’s success.

Visibility
Consumers want better visibility into their food lifecycle - where it is
coming from, how it was produced, how distribution works, etc. Big data can provide this visibility into the process.

Food quality
Big data can be used to check food quality and to help prevent any inconsistencies or problems. It also helps to ensure food manufacturers are not at risk of breaching regulations.

Traceability and audit readiness
Knowing exactly where a product is located through the manufacturing process and which suppliers/partners are involved at any given time is useful information not only for optimising the supply chain, but also in helping to comply with increasing food safety regulations.

Corporate memory
Whilst many organisations are not able to put an actual value on big data, having no understanding of, or access to, its own data can be life threatening to a business. Being able to quickly account for every document, communication and interaction can give a business the ability to make better decisions faster.

The ‘corporate memory’ is a phrase that is commonly used to describe an organisation’s historical information. It is usually a collection of documents, communications and decisions that are spread throughout the ICT landscape, from email archives, CRM solutions to files servers and content management solutions. As staffing levels change, personnel move on and the ICT landscape evolves; knowing where the information is stored is vital to making the correct decisions.

User needs
Users will generally have a set of expectations that are driven by the technology around them, from searching the internet for a restaurant. Personal searching, research and analysis is not very different to data analysis in the workplace. The key difference is the data, not the way of working and how intuitive the technology is.

As a user of a big data solution, there should be a default expectation that the solution is there to make the job easier. Usually, an assessment of the needs of the business is carried out before a decision is taken to implement an appropriate technology solution.

Unstructured data, such as that in emails, documents, PDFs and the like, forms a huge part of an organisation’s ‘corporate memory.’ Often one of the greatest challenges with unstructured data is the quality. Without a consistent data standard, (easy to enforce in a structured solution where rules can reject invalid data elements), the ability to discover and analyse is challenged. The challenge cannot be overcome with the same techniques that are employed with structured data solutions at both a technical and commercial level.

The number of variables and use cases limits users’ ability to deliver comprehensive answers using the same methods.

Software solutions
A Software as a Service (SaaS) high precision search, discovery and analysis platform can help to process existing unstructured data from a wide range of sources to deliver meaningful information to corporate managers. For example, Nalytics from Nalanda Technology is a cloud solution for extracting knowledge from unstructured data from any device. It helps individuals, teams and organisations access and analyse their data to enhance insight, drive innovation and deliver improvements. This is cutting edge technology which can deliver powerful search, analytical and explorative capabilities.

AVEBE, an international Dutch potato starch manufacturer, recognised the value in its own data and deployed the Nalytics Solution to help it make better use of historical data – quickly accounting for every document, communication and interaction. Nalytics enables the business to make better decisions and make those decisions faster. The company produces and innovates solutions based on potato starch and protein for the food, paper, building, textiles, adhesives and feed industries. An initial
assessment highlighted a need to make the company’s corporate memory more accessible to more people in a fast and efficient manner.

Cutting edge software solutions, such as Nalytics, offer the following benefits:

- **Data management - storage, searching and analysing**
  A super-fast, efficient and precise index and search solution gives users the ability to connect data from disparate locations and solution types, to search using a single interface, to discover insights in all data and to analyse the content in ways not previously considered.

- **Audit readiness**
  Being able to access all appropriate data is important, however retaining intellectual property and competitiveness is vital. With commercial threats from outside the business, a software solution can help to protect a business and data from commercial breaches that might originate from within, either accidental or intentional. Using AI techniques and a user intuitive interface, the business is empowered to protect key identifiable information.

- **Efficiency improvement**
  Users are directed to the most appropriate content first, enabling informed decisions to be taken with all relevant data to hand. By being fast and efficient, a workforce has an increased level of confidence that its decisions are accurate and effective, which in turn leads to increases in productivity and therefore efficiencies.

- **Better communication/collaboration/visibility**
  In the modern world where organisations have to work in multiple offices and across multiple time zones, being able to collaborate and evidence all workings is imperative. Users are empowered to work together either in a peer-to-peer or a management oversight capacity.

- **Improved speed/quality of decision making**
  With performance and collaboration at the forefront of the solution, decision making is cognisant of all available information in a timely manner.

- **Enhanced productivity and performance**
  By being able to reduce repetitive and procedural challenges in the work place, as well as guarantee precise accurate results, the technology allows users to make better decisions, faster.

- **Risk mitigation/enhanced food safety**
  Risk exists in every part of industry, from the supply chain to the manufacturing process. Giving the wrong advice or not making the right decision can have serious repercussions. Therefore, being able to recall the right information is vital. However, the format of information in documentation can vary. Using a consistent language across a business is challenging, particularly when a lot of documentation comes from third parties, which may use different data standards. A software solution has the ability to recall all appropriate information regardless of data standards, which helps to reduce risk.

Conclusions
As more and more food companies are seeing the benefits of utilising big data, technology is being developed to support their requirements. Big data analysis is vital to the success and longevity of a business.

A search, discovery and analysis platform can help to make better decisions possible and to improve performance and save time and money.

George Steven, Solution Consultant, Nalanda Technology, The Hub, 2 Earl Haig Road, Glasgow G52 4JU.

Established in 2013, Nalanda Technology is an independent software vendor in the electronic search and discovery space. The Company delivers innovative solutions using its core Nalytics technology that helps individuals, teams and whole organisations to explore their data and find exactly what they are looking for.

For more information about Nalytics and to find out how it could help your organisation visit www.nalytics.com or email info@nalytics.com.

www.fstjournal.org
FOOD SAFETY CERTIFICATION

Food safety through recognised certification

Certification bodies play a critical role in improving the food and drink industry’s safety management systems. **Sterling Crew** explores some of the third-party accreditation systems, which drive continuous improvement and help to give assurance that consumers can enjoy safe, healthy, and nutritious food and drink.

**The need for certification.** From horsemeat to dangerous pathogens to chemical contamination, it seems food scandals and scares are never far from the headlines. These high-profile cases dent consumer confidence creating unprecedented challenges for the food industry and yet food consumed in the UK is amongst the safest, most authentic, and nutritious in the world.

Certification bodies have made a significant contribution to improving food safety management systems (FSMS). FSMS are voluntary tools that food businesses use to enhance trust and to provide consumers with assurance that the food they buy has been manufactured safely from traceable ingredients from a secure supply network. They provide a structure for the development of safety management systems, help to mitigate risks and provide a common nomenclature and a globally harmonised approach.

The need for food and drink businesses to demonstrate competence through recognised standards and audit is now widely established within the industry and related sectors. FSMS certification is a means of strengthening due diligence and governance systems, satisfying customer requirements for manufacturers to verify their HACCP plans and demonstrating compliance to their codes of practice. Not least they provide independent endorsement of internal practices and allow food businesses to carry out their own internal ‘health checks’.

**Global Food Safety Initiative**
The Global Food Safety Initiative (GFSI) is the pre-eminent food industry programme, which provides leadership, guidance, and harmonisation on FSMS across the worldwide food supply network. Its mission is to deliver continuous improvement in FSMS to ensure confidence in the delivery of safe food to international consumers.

The GFSI was established against a backdrop of low consumer confidence along with food industry audit fatigue, as retailers and brand manufacturers audited factories against their own bespoke in-house standards. Each of these standards was developed in isolation with little or no consideration of consistency or unnecessary duplication. Conducting fewer audits increases efficiency, reduces downtime and frees up resources from customer visits to focus on innovation and new product development.

The GFSI’s objectives are:
- to reduce food safety risks by delivering convergence between effective FSMS
- to manage cost in the global food system by improving operational efficiency
- to develop competencies and capacity building to create consistent and effective global FSMS
- to provide a global stakeholder platform for collaboration, knowledge exchange and networking.

GFSI recognised food safety management schemes are shown...
in Table 1. The leading certification programme in the UK is BRC Global Standards. The BRC Global Standard for Food Safety is used by over 23,000 suppliers in 123 countries, with certification issued through a worldwide network of accredited certification bodies. The Standard is a fundamental requirement of some leading retailers.

The Standard is continuously evolving and the inclusion of methods for measuring a business’s food safety culture is under consideration. Food safety culture is increasingly cited as a significant emerging risk factor in food safety incidents and outbreaks. ISO 22000 is also a member of the GFSI family of standards. It is a scheme dealing with food safety developed by the International Organization for Standardisation and is a derivative of ISO 9000.

Other FSMS schemes
There are several other FSMS schemes that are not part of the GFSI programme, which can provide valuable assessment of food safety risks and quality assurance. The Campden HACCP Audit Scheme (CHAS) is the leading means of independently strengthening due diligence regimes and satisfying customer requirements by assurance of the appropriateness of HACCP plans. It has a relentless focus on HACCP. Similarly, the AIB International scheme, provides an excellent insight into a factory’s hygiene and GMP standards. The Sedex ethical scheme, although not FSMS based, can increase awareness about an organisation’s culture and the attitude of employees. Unsafe people make unsafe food. All these standards play their part in guaranteeing the standardisation of quality, safety and operational criteria and ensuring that manufacturers fulfill their legal obligations and provide protection for the end consumer.

Audits
Third party audits are a crucial component of maintaining food safety standards and certification. They are external audits performed by independent organisations, such as certification bodies or regulators, and are carried out to verify conformance to the standards through review of objective evidence. They are also an important management tool for driving continuous improvement in an organisation. However, audits can give a false sense of security. The audit is a snapshot in time and at its best is a sampling exercise. It is not necessarily an indicator of future performance. Although control measures are put into auditor training and calibration, there is still a possibility of some inconsistency in focus and interpretation. Audit outcomes require action and closure. Repeating the exercise without taking action is pointless. For added assurance and credibility there is an option of unannounced audits. It encourages a business to be audit ready every day and mitigates the potential peaks and troughs in factory standards, which can be driven by the audit cycle.

Over time food supply chains have grown ever more complex and many are international in nature. This creates more opportunities for unseen, unsafe food practices and for criminality. To be effective, the certification needs to be farm to fork, to cover every link in the food supply chain and to have complete and full traceability.

Legal compliance
The current economic climate has resulted in budget cuts at both the Food Standards Agency and at Local Authorities. It will inevitably impact on their ability to maintain high levels of food safety and hygiene across the food network. This challenge must be met with new ways of thinking and working. Greater emphasis will be placed on self-regulation and earned recognition, with regulators adopting a risk-based, intelligence-lead approach in which businesses can demonstrate their ability to comply with food law. Strategies covering legal compliance as a minimum requirement, such as recognition of independent third party accreditation schemes, can be adopted to ensure better targeting of resources.

Table 1 GFSI recognised food safety management schemes

- BRC Global Standard for Food Safety (Seventh Edition)
- BRC-IOP Global Standard for Packaging and Packaging Materials Issue 5
- BRC Global Standard for Storage and Distribution
- Canada GAP (Canadian Horticultural Council On-Farm Food Safety Program)
- FSSC 22000 Food Products
- Global Aquaculture Alliance Seafood - BAP Seafood Processing Standard
- Global Red Meat Standard (GRMS) 4th Edition 4.1
- IFS Food Version 6
- IFS Logistics Version 2.1
- IFS PAC secure, Version 1
- PrimusGFS Standard (v.2.1 - December 2011)
- Safe Quality Food Code 7th Edition Level 2

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Article available online at:
www.fstjournal.org/features/31-1/food-safety-certification
The challenges of reformulation for sugars reduction

Professor Julian M Cooper reviews the multi-functionality of sugars and looks at the challenges that face the product developer trying to reduce or replace sugars in foods.

Background
Reformulation is seen by many as the universal panacea for reducing sugars in foods and beverages, thus delivering healthier foods. Reformulation is identified as a key factor in HM Government’s Childhood Obesity plan (1), which proposes a broad, structured sugar reduction programme to remove sugar from the products that children eat most. The plan has challenged the food and drinks industry to reduce overall sugar across a range of products by at least 20% by 2020 (1). It quotes evidence that slowly changing the balance of ingredients in everyday products is a successful way to improve diets. Many other parties also advocate a stepwise reduction of sugar in products to deliver healthier food. Much of the evidence is based on successful reformulation of salt in a range of food products and it is assumed that sugar can be reduced/replaced in the same manner. This paper explores the practicalities of this approach and evidence is provided to demonstrate that, in contrast to salt reformulation, a sugar reduction/replacement strategy may not deliver the desired healthier benefits.

Sugar and sugars
Sugars are often referred to as sugar and sucrose (i.e. granulated sugar) is viewed as the only sugar present in food products. In fact, there are several sugars that can be present in foods, the most common are the monosaccharides glucose, fructose and galactose and the disaccharides sucrose, maltose and lactose. The occurrence, chemistry and the different ways that sugar can be defined have been reviewed in a recent Information Statement from IFST (2). Nutritional labels list all the mono and disaccharides present in a product from the ingredients and may include all the sugars mentioned above. The Scientific Advisory Committee on Nutrition (the UK Government’s advisory group, commonly known as SACN) has recommended that the definition for ‘free sugars’ be adopted in the UK (3). Free sugars are defined as all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and unsweetened fruit juices. Under this definition lactose, when naturally present in milk and milk products, is excluded.

It should be noted that it is not possible analytically to distinguish between intrinsic and extrinsic [free or added] sugars and estimates are based on the best available information.

Food Products  | Functionality delivered by sugars
--- | ---
Soft Drinks | Sweetness, mouthfeel, flavour enhancement
Confectionery | Sweetness, bulk, preservative, humectancy, colour & flavour formation, solubility, flavour release, crystal and glass formation
Baked Goods | Sweetness, bulk, humectancy, colour & flavour formation, texture modification, coating, glazing, fermentation substrate
Dairy | Sweetness, mouthfeel, flavour enhancement
Breakfast Cereals | Sweetness, bulk, colour & flavour formation, texture modification, structure forming, bowl life
Jams & preserves | Sweetness, bulk, flavour enhancement, colour & flavour formation, preservative, synergy with other ingredients
Frozen Desserts | Sweetness, bulk, flavour enhancement, freezing point depression, mouthfeel

Table 1. The functionality of sugars in food products (4)

**Functionality of sugars**
Sugars are not only sweet, they also deliver many and varied properties that are specific to different food products. They provide texture, mouthfeel, bulk, colour, flavour, preservative and humectancy. They also interact with the other ingredients present to deliver, for example, colour and flavour when processed (e.g. in cooking and baking). These different properties are summarised in Table 1. The mono and disaccharides deliver different properties, for example, sucrose is used as the standard for sweetness and has a value of 1 – the other sugars have different levels of sweetness and may also differ in sweetness quality. Together they may deliver sweetness synergy, delivering a higher level of sweetness than the individual sugars; this can be exploited in some products to reduce the amount of sugars used. A more detailed explanation of the functionality of sugars is provided in the IFST Sugars Information Statement (2).

In comparison with salt, sugars are used at higher levels and contribute many more functions to the final product – hence sugars are functionally different to salt and cannot be treated in the same manner. There is also some evidence to suggest that the factors that underlie the liking for sugar and salt may differ; test subjects quickly reverted to previous sugar...
‘liking’ levels even after several months of reduced sugar intake. This research suggests that those looking to replicate salt reduction strategies for sugar may be disappointed (4).

Sugar replacers
There are a range of sugar replacers that can be used in foods and drinks to reduce/replace sugars. Typically, they only replace one function of the sugars, sometimes two, but they cannot replace all sugars in all products. The types of ingredients that can be used as sugar replacers are summarised in Table 2.

The challenges of reformulation
In some products, the reformulation challenge is relatively easy and has already been achieved in many instances. In beverages, the sweetness of the sugars can be readily replaced with high potency sweeteners, which can be used in smaller quantities, while the bulk of the sugars is replaced by water, thus delivering a calorie reduction. In the UK, this type of reformulation has been underway for over 20 years. In 1994 the soft drinks regulations were revoked and beverages have been reformulated ever since. The UK has one of the widest choices of drinks ranging from regular sugar containing drinks to diet, sugar free options and everything in between.

Similarly, in chewing gums, it is now almost impossible to buy a sugar containing chewing gum – the sugars have been replaced by polyols, notably xylitol, which delivers excellent functionality in these products.

Other products, particularly those containing significant levels of starch and/or fat combined with sugars, are more challenging to reformulate.

The key issues encountered with reformulation are: increased numbers of ingredients, ingredients that consumers are not familiar with and would not be found in their kitchen cupboards, increased warnings on pack, insignificant changes to the energy content of products and a potential impact of food safety. These issues will be illustrated using the examples below.

Increased and unfamiliar ingredients
Traditionally sugars have been used to preserve foods providing nutritious and safe foods outside the usual harvest season e.g. jams, preserves, chutneys. A sugar free preserve from the USA illustrates the number of additional ingredients that are required to deliver a similar product without the use of sugars. This approach does however deliver a reduction in calories – regular jam contains 243 kcal/100g, while sugar free preserve contains 58 kcal/100g. The ingredient declaration for the two products is presented in Figure 1.

In regular jam, sugar is performing many functions – it provides sweetness, bulk and high solids, which assist the setting of pectin. The citric acid provides a low pH, which results in inversion of the sucrose to give glucose and fructose and thus increases the number of molecules present, increasing the preservative action of the sugars. The reducing sugars glucose and fructose also react providing flavour and colour to the jam.

Replacing sugars in jams increases the number of ingredients: regular jam contains four ingredients, while sugar free preserve contains twelve. In the sugar free preserve, sucralose (a high potency sweetener) provides the sweetness, polydextrose and maltodextrin (bulking agents) and pectin (gelling agent) provide bulk and texture to the product. Most of the bulk is provided by high molecular weight compounds because regular High Methoxy pectin will not gel – the sugar free preserve relies on the action of calcium (chloride) to gel the Low Methoxy pectin present. Again, due to low numbers of molecules, the water activity (a_w) is high and a preservative (potassium sorbate) is required to maintain shelf life. The addition of flavour and colour is required to maintain the appearance and taste of the product.
Increased warnings on label

The use of many sugar replacers is controlled by the Additives Regulation EU Regulation 1129/2011. This regulation specifies which additives can be used in which products and also sets limits and conditions for use. Two labels that also must accompany the use of specific additives are ‘contains a source of phenylalanine’ for products containing aspartame and ‘excessive consumption may cause laxation’ for products containing above 10% polyols. Both aspartame and polyols are additives that can be used to replace/reduce sugars in food products.

Negligible change in energy content

When consumers see a reduced sugars claim, they expect to see a resultant reduction in energy. Research at Leatherhead Food Research [6] has indicated that consumers see sugar as a proxy for calories and expect a reduction in calories if a reduced sugars claim is made on pack. This is illustrated in Figure 2, which shows an expectation of a similar reduction in calories for each reduction in sugar in a product.

The Childhood Obesity plan [1] also highlights that sugar reductions should be accompanied by reductions in calories and should not be compensated for by increases in saturated fat. In practice this is very difficult to achieve in many products as illustrated by the following examples:

(i) Breakfast cereals

Breakfast cereals are composed principally of starch from a number of cereal grains – wheat, corn, oats etc. The sugars are added to provide structure, taste and colour. Starch and sugars are carbohydrates and both have 4 kcal/g. Consequently, when sugars are reduced in cereal products, there is a negligible change in the energy content of breakfast cereals [without the addition of fibre]. This is illustrated in Table 3. The data has been collated from the nutritional panels of 3 breakfast cereals from the same company. Even though there is a significant reduction in sugars – 40% and 78% respectively, there is very little change in the energy provided per bowl (30g) of cereal: 113 and 114 kcal respectively. As the sugars are reduced, the starch becomes a higher percentage of the cereal and thus there is no change in calories.

(ii) Stepwise reduction in shortbread

The challenge is very similar with biscuit products – Table 4 (p41) illustrates a stepwise reduction in sugar in a shortbread recipe. Reducing sugar in the recipe might be expected to result in a significant calorie reduction, however as the sugar is reduced, the fat (butter) becomes a higher proportion of the product and as fat has 9 kcal/g, the calories actually increase. Therefore, a simple stepwise reduction of sugar in this product will not deliver the anticipated calorie reduction.

(iii) Calorie increase

The Food and Drink Federation...
and Leatherhead Food Research recently published a guide to assist small and medium sized companies with reformulation. They highlighted a product containing fat, starch and sugars which, when reformulated to give a 36% reduction in sugars, actually delivered an increase in calories.

The change in composition required an increase in fat, starch and protein to balance the reduction in sugars (Table 5). It is also important to note that this product would not be allowed to use a reduced sugar claim as it has an increase in calories. EU Commission regulation EU No 1047/2012 states that the claim ‘reduced sugars’, and any claim likely to have the same meaning for the consumer, may only be made if the amount of energy of the product bearing the claim is equal to or less than the amount of energy in a similar product. (iv) Food safety

Water is ubiquitous in foods and the amount and availability determine the shelf life of many products. Sugars are highly soluble and thus influence the water activity in many systems. The ability to retain water and in some cases even attract water (hygroscopicity) can also influence the texture of many foods. Problems can occur if sugars are reduced or replaced in food products; a well-documented outbreak of botulism in 1989 was associated with the replacement of sugar with aspartame in hazelnut puree products. Sugar was providing preservative benefits and preventing microbial growth in the processing and storage; replacement with aspartame changed the \( a_w \) and allowed the growth of \( Clostridium botulinum \) in the product. This resulted in one death and 27 people suffering from botulism poisoning.

**Conclusion**

Sugar reformulation in food products is seen by some as the universal panacea for the obesity crisis. However, sugar reduction/replacement is not as straightforward as salt reformulation and may result in unintended consequences. Reformulation and, in particular, stepwise reduction may result in increased calories. Replacement with other ingredients is likely to require an increased number of additives unfamiliar to the consumer. To produce healthier (lower calorie) food products, a holistic approach must be taken to redesign foods so that ingredients deliver the maximum impact at the optimal level. Care must also be taken to avoid the ‘halo’ effect, where healthier products are seen as better: ‘therefore I can eat two’!

**Professor Julian M Cooper**

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Julian is a carbohydrate chemist with over 35 years’ experience in the food industry. He is a visiting professor at the University of Reading and chairs the scientific committee at IFST, where he is also a Board Trustee. In 2015 he retired from Associated British Foods (British Sugar) and is now an independent consultant to the food industry. Julian is the author of the IFST peer reviewed Sugars Information Statement.

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**Table 4. Stepwise reduction of sugar in a shortbread recipe**

<table>
<thead>
<tr>
<th>Weight of sugar in recipe g</th>
<th>Sugars reduction %</th>
<th>Calculated calorie reduction*</th>
<th>Sugars g/100g</th>
<th>kcal/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0</td>
<td>0</td>
<td>14.9</td>
<td>463</td>
</tr>
<tr>
<td>45</td>
<td>10</td>
<td>20</td>
<td>13.6</td>
<td>464</td>
</tr>
<tr>
<td>40</td>
<td>20</td>
<td>40</td>
<td>12.3</td>
<td>465</td>
</tr>
<tr>
<td>35</td>
<td>30</td>
<td>60</td>
<td>10.9</td>
<td>466</td>
</tr>
</tbody>
</table>

*Calculated calorie reduction = weight of sugar removed from recipe x 4 kcal

**Table 5. Effect of reducing sugars without replacement of a lower calorie ingredient in a product example with 22% sugars and 23% fat**

<table>
<thead>
<tr>
<th>Typical Values</th>
<th>Product before reducing sugars (g per 100g)</th>
<th>Product after reducing sugars (g per 100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>23.0</td>
<td>25.3</td>
</tr>
<tr>
<td>Saturates</td>
<td>11.0</td>
<td>12.1</td>
</tr>
<tr>
<td>Monounsaturates</td>
<td>8.8</td>
<td>9.7</td>
</tr>
<tr>
<td>Polysaturates</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>63.0</td>
<td>59.3</td>
</tr>
<tr>
<td>Total sugars</td>
<td>22.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Starch</td>
<td>41.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Fibre</td>
<td>3.8</td>
<td>4.2</td>
</tr>
<tr>
<td>Protein</td>
<td>6.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Salt</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>[Ash]</td>
<td>2.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Energy</td>
<td>2063kJ</td>
<td>2105kJ</td>
</tr>
<tr>
<td></td>
<td>494kcal</td>
<td>503kcal</td>
</tr>
</tbody>
</table>
Food manufacturers and retailers are constantly innovating to set or respond to trends, such as the current requirement to reduce or replace sugar in key product categories. Creating a product blueprint can take the guess-work out of innovation, ensuring none of the process is left to chance.

A blueprint of a product is a map showing the ingredients, the state of the ingredients, how they are distributed throughout the product and which ingredients are responsible for the product properties. Armed with this knowledge, the manufacturer can set baselines for innovation and carry out a number of important activities with confidence, including:

- Reformulating to respond to trends such as ‘natural’, ‘clean label’, ‘reduced sugar’ and the demand for healthier foods
- Producing a consistently high quality product anywhere in the world by understanding the impact of production
- Responding to new developments in manufacturing processes, packaging or preservation methods
- Conforming to different regulatory requirements

**How to create a blueprint**

A number of techniques are used to develop a blueprint for a product. Microscopy, rheology and sensory profiling are key. These should be combined with chemical information and shelf life studies to create the complete blueprint. This can then act as a baseline for your innovation, helping you make product changes with confidence.

To explain how Leatherhead builds a blueprint, take the example of a biscuit. The crumb of a biscuit is key to the texture; this can be clearly seen using simple light microscopy. More information on the nature of the ingredients and their distribution can be obtained by cutting thin slices through the biscuit and using polarised light or staining to show the location and state of the ingredients. The images below show a standard biscuit made with sugar contrasted with one using a bulk sweetener.

Scanning electron microscopy can be used to show the three-dimensional crumb matrix in more detail and obtain information on the location of ingredients, such as fat and salt. The microstructure reflects the result of the formulation and the manufacturing process and is such key to delivering the blueprint of the product. Additionally, instrumental texture analysis provides quantitative information on properties, such as the hardness, brittleness and elasticity of products. This technique is ideally combined with sensory profiling to give a descriptive map of the important sensory attributes to which the microstructure is related.

As the images show, a simple exchange of sugar for sweetener altered the colour, structure and texture of the biscuit, as well as the distribution of fat, starch and protein. These changes can be mitigated to some extent; however, to produce a sugar-free product, which has the same texture and properties as the standard biscuit, requires an understanding of why changes to the product’s properties have occurred.

**Blueprints in action**

In the next few years, we expect companies that use the blueprint as a development tool to have a significant advantage over those that do not. An increased understanding of product behaviour builds rapidly as does the ability to make very specific improvements to products and anticipate the consequence of formulation changes.

If you have a reformulation challenge in your business and want to understand how blueprinting can help, then please contact us at help@leatherheadfood.com. Remember, the scientific method of creating product blueprints takes the guess-work out of reformulation.
CAREERS & TRAINING

Careers and training in the food and drink sector

Food Technical Degree Apprenticeship

Sue Densley of The National Skills Academy for Food & Drink describes progress towards the establishment of Degree Apprenticeships for food technical professionals.

The Degree Apprenticeship is a four-year programme which embeds a BSc (Hons) Food Science and Technology degree alongside a structured work-based training programme. This combination provides an attractive career path for individuals wishing to progress into technical professional roles, including Assistant Food Technical Managers, Quality Managers, Shift Quality Managers, Hygiene Managers, Product Innovation and Development Technologists. Ensuring the safety and quality of food products, by improving existing products and launching new ones that are key to growers, food manufacturers and retailers, is at the core of this Degree Apprenticeship.

Producing a degree apprenticeship programme, as with other apprenticeships, involves writing a two-page standard, which covers the knowledge, skills and behaviours that an individual needs to exhibit at the end of the programme and the development of an end point assessment to test these elements. The Food Industry Technical Professional Degree Apprenticeship standard is available at the website below.

Janette Graham, Group Technical Learning and Development Manager at 2 Sisters Food Group, chairs the employer group, supported by the NSAFD, which has been working with the National Centre for Food Manufacturing at the University of Lincoln, Nottingham Trent University, Chester University, Reading University, Greenwich University and the IFST to develop the standard and the assessment plan. She says ‘I am delighted to be leading on a development which will underpin the future delivery of food technical apprenticeship degree programmes. We are excited by a programme which will have the rigour of a degree, whilst enabling the employer to directly work with an individual to obtain the skills needed in the workplace.’

The employer group is in the process of completing the assessment plan, which it is hoped will be published in the spring, in time for the wider university sector to offer degree apprenticeships from September 2017.

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Article available online at: www.fstjournal.org/features/31-1/careers-training/degree-apprenticeship
Degree Apprenticeships addresses shortage of food technologists

Sharon Green from the National Centre for Food Manufacturing at the University of Lincoln, one of the universities involved in developing the Degree Apprenticeship programme, explains how the apprenticeships will bring together the best of higher education and vocational training to plug the skills gap in food manufacturing.

Apprenticeship reform
Thanks to an injection of Government funding to develop Degree Apprenticeships, young people will have greater opportunity to forge a career within the food industry and benefit from being able to ‘earn while they learn’ as degree level career paths become established in the sector.

Degree Apprenticeships are a result of the Government’s commitment to grow apprenticeship participation, particularly at the higher levels, and to put employers at the helm of apprenticeships by involving them directly in the design of new programmes through the introduction of the apprenticeship levy. From April 2017, large eligible businesses will pay a levy to support apprenticeship training. Smaller businesses are expected to indirectly benefit from the levy too. Employers are therefore keen to use the opportunity afforded by the levy to support apprenticeship training. Smaller businesses are expected to indirectly benefit from the levy too. Employers are therefore keen to use the opportunity afforded by the levy to support apprenticeship training.

The University of Lincoln’s National Centre for Food Manufacturing (NCFM) has secured a share of the Government’s £4.5 million Degree Apprenticeship Development Fund to help ensure the sector has the relevant Degree and Higher Apprenticeships in place when the levy is introduced. It is leading a pioneering project to develop the food industry’s first Degree Apprenticeships. NCFM is working with project partners – Sheffield Hallam University’s National Centre of Excellence in Food Engineering and the National Skills Academy for Food & Drink (NSAFD) – to develop and deliver Degree Apprenticeship programmes for the key occupations of Food Engineering, Operations Management and Technical Management roles, launching from September 2017.

Support from the sector
The Government’s drive to grow Degree Apprenticeships has been well received by food industry employers. The food and drink industry represents the single largest manufacturing sector in the UK, contributing more than £100 billion to the national economy. The sector is highly innovative and is already adopting many advanced technologies which require ready education for the food industry. The staff at NCFM have experience of working in the food industry and in supporting part-time learners; they understand the demands faced by food industry employees who are studying while working and often balancing family commitments at the same time. To meet these needs, NCFM has developed a range of apprenticeships and higher education programmes which are underpinned by flexible study options. The majority of the 110 individuals enrolled on NCFM’s Food Manufacturing degrees are employed in Quality and Technical Management roles and are studying on this specialist pathway.

The Food Industry Technical Professional Degree Apprenticeship is a four-year programme which embeds a BSc (Hons) Food Science and Technology degree alongside a structured work-based training programme. This combination provides an attractive career path for individuals wishing to progress into technical professional roles including Assistant Food Technical Managers, Quality Managers, Shift Quality Managers, Hygiene Managers, Product Innovation and Development Technologists. Ensuring the safety and quality of food products is at the core of this Degree Apprenticeship.

The higher level skills needed by employers, while offering young people an alternative to the traditional degree course. Degree Apprenticeships will enable more people to study in higher education and work at the same time, as they can access flexible programmes provided by universities supported by distance learning.

National Centre for Food Manufacturing

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access to higher level skills. By blending high-quality workplace training with part-time, flexible degree level study, these programmes are specifically designed to address this need. With the food and drink manufacturing industry at the forefront of this new way of training, there is confidence that the valuable combination of practical experience and higher education will both attract young talent and reward and enhance the abilities of existing employees.

The Food and Drink Federation (FDF) and many leading food businesses, including Nestle, 2 Sisters Food Group, Princes and Moy Park, are directly supporting the development of NCFM’s Degree Apprenticeship programmes. Angela Coleshill, the Competitiveness Director at the FDF, has explained that the food and drink industry will need 130,000 new recruits by 2024 to meet the sector’s skills needs. The FDF believes that this type of collaborative working between industry and educational institutions will provide the next generation of advanced engineers and leaders.

Collaboration is key
The University of Lincoln’s NCFM offers employer-driven further and higher education for food science and technology based roles; the introduction of the new Degree Apprenticeships builds on the success of existing Advanced Apprenticeships, Higher Apprenticeships, undergraduate and post graduate courses. Its nationally accredited Advanced and Higher Apprenticeship work-based programmes already support employers by providing professional qualifications to all ages and abilities in food science and technology related job roles.

With long-established industry relationships and a range of vocational short courses, the team at NCFM aims to ensure that everyone – from new starters through to existing employees – can access relevant study and training options. By accessing additional short courses, for example the IFST’s Sensory evaluation, individuals can further their own careers and provide the higher level skills the sector demands, in terms of technical knowledge, professional abilities and wider business competencies.

The team at NCFM has been involved in a number of employer consultations to provide guidance to businesses and ensure the courses on offer are meeting industry needs. Contact from companies looking to find out more about the Food Industry Technical Professional Degree Apprenticeship is welcomed.

Cutting-edge facilities
As well as working with leading employers in the food and drink industry, the Degree Apprentices will benefit from access to cutting-edge facilities at NCFM. From its base in Holbeach in southern Lincolnshire, NCFM provides expertise on industry needs and hosts pioneering research, development and training projects in a model food manufacturing plant. A new Centre of Excellence in Agri-food is also planned, which will house larger food microbiology and chemistry laboratories, together with an upgraded test kitchen and sensory suite, a learning resource centre and accommodation for seminars and business networking events. The imminent expansion of the University’s facilities also represents the first stage of development for the new Food Enterprise Zone in Holbeach.

In recent years, the University of Lincoln’s work for the agri-food industry has focused on research in robotics and automation for the sector. NCFM is home to the pioneering APRIL (Automated Processing Robotic Ingredient Loading) system, which has been developed by OAL. APRIL is a ‘robotic chef’ that combines cutting-edge food processing technologies with proven robotic systems to produce high-quality food on an industrial scale (p18).

Changing times
The industry is experiencing momentous change as the living wage and other drivers of cost inflation fuel the large-scale adoption of advanced technologies that require ready access to higher level skills. An acute shortage of these skills is already presenting a significant challenge to the sector so attracting new talent and upskilling existing workforces is absolutely crucial.

At the heart of the Government’s apprentice reforms is the drive for greater employer ‘ownership’. The involvement and leadership of food businesses from across the industry will ensure that apprenticeships at all levels deliver the required knowledge, skills and behaviours.

The Government’s drive to grow Degree Apprenticeships has been well received by food industry employers.

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Direct analysis of glyphosate in wine

Sharanya Reddy and Frank Kero of PerkinElmer, Inc. and Matteo Meglioli of Mosti Mondiale describe the analysis of glyphosate in wine with no sample preparation using QSight™ 220 LC-MS/MS system with a ‘Stay Clean’ source.

Introduction
Glyphosate is an organophosphate herbicide that is used on crops to kill weeds and grasses. Its usage has multiplied with the introduction of transgenic crops made resistant to glyphosate. Because of its rampant use, it is not surprising that glyphosate has been detected in a variety of foods. Recently, the International Agency for Research on Cancer classified glyphosate as ‘probably carcinogenic in humans’.

In lieu of regulatory bodies setting limits on glyphosate in food, it becomes imperative to develop robust and sensitive analytical methods for glyphosate detection. Since glyphosate is a very polar molecule, it does not retain well on a traditional reverse phase column making it very difficult to chromatographically separate from other components and detect. Methods involving derivatisation with a hydrophobic moiety can help retain glyphosate on the column but also makes the process labour intensive and tedious. We present a study that involves direct analysis of glyphosate in wine on a mixed mode column with no sample dilution or extraction using a PerkinElmer QSight™ 220 triple quadruple mass spectrometer with a unique Stay Clean™ source consisting of a hot surface induced desolvation (HSID)™ interface and a laminar flow ion guide™. Both the HSID and ion guide prevent any contaminants from entering the mass spectrometer, keeping it at its highest performance and thereby maintenance free.

Experimental
Wine samples were filtered through a nylon filter (0.2 μm) and spiked with known concentrations of glyphosate and its degradation product amino methyl phosphonic acid (AMPA) to set up a calibration curve. The samples (20 μL) were directly injected on an LC column (Acclaim Trinity Q1 100 x 3

Fig. 1. Overlay of MRM chromatograms of a triplicate analysis of 5 ppb glyphosate spike in a red wine sample.
mm 3μm) using the Altus™ UPLC® system fitted with the PerkinElmer QSight 210™ series mass spectrometer. Chromatographic separation was performed with gradient elution using mobile phases A (50 mM ammonium formate, pH adjusted to 2.9 with formic acid) and mobile phase B (acetonitrile). The glyphosate and AMPA were analysed in multiple reaction monitoring (MRM) mode. The MRM transition ions 109.7>78.8 and 109.7>62.8 were monitored for glyphosate and the transition ions 167.5>63 and 167.5>78.8 were monitored for AMPA.

Results and discussion
The glyphosate spiked in red and white wine samples was analysed in multiple reaction monitoring (MRM) mode and was easily detectable at 5 parts per billion (ppb) with no sample preparation in both red (Fig.1) and white wine. The signal to noise (S/N) of 200 obtained for the 5ppb glyphosate spike in red wine suggested we should be able to detect the analyte at concentrations lower than 5 ppb.

The calibration curves of glyphosate and AMPA spiked in red and white wine showed excellent linearity (r2> 0.996) and the peak area intensity was similar for the analyte in both matrices suggesting that red wine, in spite of being heavily pigmented, did not suppress/interfere with the signal.

The robustness of the ‘Stay Clean’ source was tested by analysing nearly 300 injections (20 μl each) of red wine. As seen in Fig.2, there was minimal loss of signal of glyphosate (RSD<10%), indicating the source was robust to contamination from dirty matrices.

The HSID interface is gently transferred by gas flow to the laminar flow ion guide present in the QSight mass spectrometer. Unlike traditionally designed interfaces, the HSID with its multi-channels orthogonal to each other produces turbulent and laminar flow which disrupts the free jet expansion of the sample ions. The orthogonal channels prevent neutrals from entering the mass spectrometer reducing chemical noise and any solvated charged clusters entering the HSID are entrained and desolvated in the hot flow of gas further contributing to reduction in chemical noise.

In these regions, pressure gradually drops, creating a well-defined flow pattern along the ion path enabling ions to be gently extracted into the analyser. Both the HSID and laminar flow ion guide prevent accumulation of contamination along the ion path making the QSight maintenance-free. The many benefits of the HSID interface include high sensitivity due to an inherent reduction in chemical background and the ability to perform analysis at high LC flow rate (3mL/min) without reduction in signal.

The QSight triple quadrupole mass spectrometer is fitted with a unique low maintenance source that allows for minimal sample preparation thereby resulting in increased productivity.

Sharanya Reddy and Frank Kero, PerkinElmer Inc, Shelton, CT, and Matteo Meglioli, Mosti Mondiale, Inc, Quebec, Canada.
Neogen develops superior chromogenic media for *Salmonella*

Neogen’s Lab M has developed a unique chromogenic media that offers a superior ability to simultaneously detect numerous strains of *Salmonella* of concern to the food and animal feed industries, while inhibiting or minimising other organisms.

This new Chromogenic Agar for *Salmonella* Esterase (CASE) uses a proprietary dual chromogenic system to differentiate between *Salmonella* and non-target organisms that grow on the agar. The new media, available in pre-poured plate or dehydrated culture media (DCM), is suitable for use within the ISO 6579 protocol — the international standard for testing food and animal feed for *Salmonella* species.

Currently available *Salmonella* chromogenic media typically produce pink-purple colonies that are sometimes hard to distinguish — whilst this new agar gives turquoise-blue and black colonies that are very easy to identify particularly with low C8-esterase activity *Salmonella* strains,’ said Steve Chambers, Neogen’s European sales and marketing director. ‘CASE media also is able to detect specific *Salmonella* serovars that are often missed by existing media, including non motile and weaker strains such as *S.* Dublin, reducing the risk of reading false negative results.

The media was developed at Neogen’s Lab M facilities specifically for food and animal feed manufacturers, as well as poultry and pork processors.

CASE detects a wide range of *Salmonella* species and has been shown to produce enhanced specificity in the detection of important *Salmonella* serotypes, including *S.* Gallinarum, *S.* Pullorum and *S.* Dublin. *S.* Gallinarum causes mortality of up to 100% in poultry of any age; *S.* Pullorum also causes high mortality, but in young birds; *S.* Dublin causes a 50% mortality rate in cattle and is of particular importance as it can potentially spread to humans. Additionally the formulation of CASE means growth from background flora is significantly reduced and closely related *Enterobacteriaceae*, such as *Citrobacter* and *Enterobacter*, are clearly defined. This makes difficult matrices easier to read and can significantly reduce the amount of unnecessary confirmations required, which can be costly and time-consuming.

Neogen can supply the CASE media fully ready to use as part of Lab M’s Pinnacle™ pre-poured media range, which includes all necessary supplements with no need to weigh, cool or autoclave media. Alternatively, the CASE media is available pre-supplemented in DCM format as part of Lab M’s Harlequin™ chromogenic media range.

For more information or to arrange a free sample simply call +44(0) 1292 525 625 or email microbiology_uk@neogeneurope.com.

Neogen Corporation (NASDAQ: NEOG) develops and markets products dedicated to food and animal safety. The company’s Food Safety Division markets dehydrated culture media and diagnostic test kits to detect foodborne bacteria, natural toxins, food allergens, drug residues, plant diseases and sanitation concerns. Neogen’s Animal Safety Division is a leader in the development of animal genomics along with the manufacturing and distribution of a variety of animal healthcare products, including diagnostics, pharmaceuticals, veterinary instruments, wound care and disinfectants.
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Testing for emerging organisms of concern

Catherine Cockcroft of Eurofins discusses the right time to start testing for emerging organisms of concern.

The media continually makes us aware of new threats that the food industry seemingly needs to worry about. Differentiating the true emerging organisms of concern from the background noise is difficult and addressing those threats within food businesses is even more of a challenge. Responsible parties must recognise the hazards relevant to their products, assess the risks and manage them through the use of HACCP principles and pre-requisite programmes. Microbiological testing can provide verification that HACCP and GMP are under control. However, verification testing for some of the emerging organisms of concern may not be straightforward to carry out and it may be even more difficult to interpret the results.

Foodborne viruses, including Norovirus, Hepatitis A and Hepatitis E, cannot grow or multiply on foodstuffs, but products, such as bivalve molluscs, leafy vegetables and berries, contaminated with water containing infected human waste can act as vectors for their transmission to humans via the faecal-oral route. Resulting illness can vary from self-limiting gastrointestinal symptoms to more serious liver inflammations. While the true burden of illness attributable to contaminated food is not known, it is estimated that Norovirus is the most common cause of foodborne illness in the European region with close to 15 million cases each year, causing more than 400 deaths (source: WHO estimates of the global burden of foodborne diseases: foodborne disease burden epidemiology reference group 2007-2015).

Testing foodborne viruses in foods is challenging, particularly the recovery of low levels of strongly adherent viral particles, which may be protected in microscopic crevices or within the digestive gland of bivalve molluscs. The best methods available may only recover 1% of the viral particles present in the food. Complex molecular techniques detect the presence of viral particles and results are expressed in numbers of viral genome copies. Detection in itself does not necessarily mean that the people consuming the food are at risk of foodborne illness. The infective dose from foods is not known, though may be as low as 10 viral particles.

Furthermore, the presence of viral RNA does not necessarily mean that the particle is capable of infectivity. Another consideration is the cost of performing the testing. Molecular techniques, unlike conventional cultural microbiology methods, are expensive and complex to perform, increasing the cost per test from a few pounds to perhaps a few hundred pounds.

Clearly, testing does not assure food safety, and producers/manufacturers already have procedures in place that minimise the risk of contamination of the foods by foodborne viruses. Given the information gaps that currently exist, should food businesses already be testing for foodborne viruses to verify the effectiveness of the controls that they have in place? If viral particles are detected on foodstuffs, what remedial action should the food business take? Is there a risk that product will be removed from sale when it does not present a true risk to the consumer. Or is the risk greater to the consumer if food businesses choose not to perform any verification testing. At this early stage in the understanding of these micro-organisms, caution is advised before rushing into full scale routine testing.

Producers and manufacturers should anticipate how they will react to detection of these organisms and be ready to enact those processes should the need arise. In the meantime, research to better understand these organisms, and to plug the knowledge gaps continues. Methods for their testing are being refined and improved. In 3-5 years, we may be in a position to include these organisms in routine verification testing of at risk foodstuffs.

Eurofins offers ISO 17025 accredited Norovirus and Hepatitis A Virus testing of foodstuffs from our network of European laboratories. For more information contact our UK laboratory on 0845 604 6740 or email sales@eurofins.co.uk.

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