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Our theme for March is new sources of protein for human food and animal feed. With the global population increasing and the rise of the middle classes, demand for meat is growing rapidly. There is an imperative need to find alternative, more sustainable sources of protein, such as vegetables, algae, microorganisms, insects and cell-cultured meat, which use less ecosystem resources and less land. Conventional sources of protein will not be adequate to meet the demands of the growing global population. Insect protein has already begun to appear in human foods and research is underway to identify optimum species and production conditions (p33, p35). Insect protein also offers the potential to provide new functional ingredients for foods, with the ability to generate, for example, gels, emulsions and foams (p36).

While in many eastern countries, insects are appreciated as delicacies, in western countries the adverse response to eating insects must be overcome if we are to provide sufficient protein for the future population. Aquaculture has been expanding to meet protein requirements, with fish being more efficient at retaining carbon and energy from feed than livestock (p28). The high cost of conventional animal foods, such as soybean and fishmeal, is increasing the demand for new protein sources for feed. Insect protein is showing highly promising characteristics in terms of nutritional value and environmental footprint for both livestock farming and aquaculture, offering the potential to use waste feedstocks (p32, p38). Algae are also appearing as an alternative to fishmeal (p30) and as a source of protein for human nutrition – they are being offered as high protein snack bars (p36). Innovative research has identified a compound that is important in the production of meat flavour and this has led to the development of an alternative route for producing the compound using yeast fermentation (p32). As a result, a vegetarian burger has been launched in the US that looks and tastes like meat.

In this issue, we are introducing a new section on Brexit viewpoints (p36), in which individuals across the food sector will contribute opinions about the impact and planning of Brexit. Please get in touch with me if you are interested in contributing to this section.

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Future of food

A new report from the European Academies' Science Advisory Council (EASAC) is calling for urgent action on food and nutrition security [1]. A team of scientists from 130 science academies across Europe undertook a two-year extensive analysis on the future of food, nutrition, agriculture and health and concluded that Europe will need to change its diet in the future to address climate change and health.

Food consumption will need to change to improve consumer health:
• A decrease in the consumption of animal protein could be important for both health and the environment.
• Policy-makers should tackle the perverse price incentives to consume high-calorie diets and introduce new incentives for affordable nutrition.
• More clarity is needed about how to measure sustainability related to consumption of healthy data.
• Sources of food contamination must be characterised to tackle food safety concerns.
• European countries must commit to collection of more robust data on waste in food systems and the effectiveness of interventions to reduce waste.

Farming and agriculture have many questions remain from a scientific perspective. The report concludes that Europe must accept the use of large data sets:
• European policy-makers should capitalise on the scientific advances in genomics for animal and crop health and productivity.
• Wild gene pools need to be protected and characterised.
• Large data sets should be used to support innovation throughout the food system, for example in precision agriculture, and prepare for risk and uncertainty.

Underpinning the scientists’ recommendations is a clear call to integrate research and innovation across the disciplines into all of these topics, where many questions remain from a scientific perspective. The report concludes that Europe must capitalise on opportunities to co-design research to understand better the relationship between food, water and ecosystem services. It recommends being more ambitious in identifying scientific opportunities to shape understanding of both supply- and demand-side challenges.
Acrylamide legislation

Food business operators (FBOs) in the UK will be required to put in place practical steps to manage acrylamide within their food safety management systems under new EU legislation which will apply from April 2018[5]. The legislation describes practical measures based upon best practice, mitigation measures and benchmark levels for the reduction of acrylamide in food.

Acrylamide forms naturally during high temperature cooking and processing, such as frying, roasting and baking, particularly in potato-based products and cereal-based products. It is not possible to eliminate acrylamide from foods, but actions can be taken to try and ensure that acrylamide levels are as low as reasonably achievable.

Mitigation methods have been drawn from the various codes of practice that have been developed by various sector specific trade bodies who have investigated how to reduce acrylamide in different foods.

Benchmark levels are generic performance indicators for the food categories covered by the Regulation. They are not intended to be used for enforcement purposes.

Industry guidance has been developed by various food sectors at national and EU level, including the acrylamide tool box maintained by Food Drink Europe. The Food Standards Agency (FSA) and Food Standards Scotland (FSS) are working with the British Hospitality Association (BHA) and other trade associations to develop a best practice guide for FBOs in the catering and foodservice industry. This is expected to be finalised and available from the BHA in early 2018. The FSA is also developing guidelines to assist local authorities in the implementation and enforcement of the new requirements.

Food Business Operators will be expected to:

• Be aware of acrylamide as a food safety hazard and have a general understanding of how acrylamide is formed in the food they produce
• Take the necessary steps to mitigate acrylamide formation in the food they produce, adapting the relevant measures as part of their food safety management procedures
• Undertake representative sampling and analysis where appropriate, to monitor the levels of acrylamide in their products as part of their assessment of the mitigation measures
• Keep appropriate records of the mitigation measures undertaken, together with sampling plans and results of any testing.

The measures are intended to be proportionate to the nature and size of the business, to ensure that small and micro-businesses are not burdened. The new legislation applies to all FBOs that produce or place on the market the following foods:

• French fries, other cut (deep fried) products and sliced potato crisps from fresh potatoes
• Potato crisps, snacks, crackers and other potato products from potato dough
• Bread
• Breakfast cereals (excluding porridge)
• Fine bakery wares: cookies, biscuits, rusks, cereal bars, scones, crumpets, weavers, croissants and gingerbread, as well as crackers, crisp breads and bread substitutes
• Coffee (ⅻ espresso coffee (ii) instant (soluble) coffee
• Coffee substitutes
• Baby food and processed cereal-based food intended for infants and young children

Different requirements apply to local and independent FBOs selling food directly to the consumer or directly into local retail, for example, independent cafes, fish and chip shops and restaurants. For larger centrally controlled and supplied chains with standardised menus and operating procedures, the controls of acrylamide can be managed from the centre.

An inspector calls

The Health and Safety Executive (HSE) commenced a programme of unannounced inspections to review health and safety standards in food manufacturing businesses across the country from January 2018[6].

• The inspections are focused on two of the main causes of ill-health in the sector:
  • occupational asthma from exposure to flour dust in bakeries, cake and biscuit manufacturers and grain mills and
  • musculoskeletal disorders (MSDs) – predominantly lower back pain and upper limb disorders from manual handling activities and repetitive tasks across the sector.

• The inspections follow the release of HSE’s Manufacturing sector plan, which prioritises the reduction of cases of occupational lung disease and MSDs.

• Exposure to flour dust is the UK’s second most commonly cited cause of occupational asthma. MSDs are the most common type of work-related illness in food manufacturing with handling injuries accounting for around 20% of reported employee injuries. HSE insists that such ill-health can be prevented when organisations have proper risk control systems in place.

• The inspections ensure measures are being taken by those responsible to protect workers against health risks and HSE states that it will not hesitate to use enforcement to bring about improvements. It is also calling on those working in the industry to refresh their knowledge of its advice and guidance, available on its website.


Industry consultation

A new Campden BRI consultation has identified the challenges that food industry can be tackled by the food industry using science and technology[8].

The consultation gathered over 600 face-to-face contributions covering the entire food supply chain and including a survey of Campden BRI’s 2,400 members in 75 countries.

Some of the new challenges identified during the consultation were:

• Sustaining product quality in the face of rising costs of operations and materials
• Soil health – stronger regulation of soil as a resource and methods for its protection
• Human microbiota – understanding and harnessing of the gut microbes in diet-related health conditions
• Anti-microbial resistance – detection and reduction of the ‘anti-bug’ era (e.g. Internet of Things, ‘Big Data’ and AI [artificial intelligence])

Some of the needs raised are more long standing but continue to feature in the consultation.

The consultation highlighted consumer preference for higher food safety, encouraging consumer wellbeing through healthy diets, protecting consumers against food fraud, tackling industry’s skills shortage and encouraging sustainable supply chains with reduced use of resources.

While Brexit does not represent a scientific need, it did feature in many of the discussions with UK and EU food and drink companies – in particular, regulatory change and uncertainty, potential changes to labour and impact on costs of ingredients, raw materials, packaging and distribution – where the consequences of Brexit will require regulatory and technical solutions.

The UK Parliament’s Environmental Audit Committee has issued two new reports on plastic recycling in the UK addressing plastic bottles and disposable coffee cups lined with plastic.

The first report, published in December 2017[7], reveals that in the last 15 years, consumption of bottled water in the UK has doubled such that water bottles now make up around half of all plastic bottles. We use 13 billion plastic bottles every year and only 7.5 billion are recycled. The remaining 5.5 billion arelandfilled, littered or incinerated. Plastic bottles make up a third of all plastic pollution in the sea. In the recent BBC Blue Planet II documentary[9], David Attenborough highlighted the dangers for marine animals created by plastics in the oceans and the potential risk of plastic uptake to the whole food chain.

The Environmental Audit Committee has recommended that the Government introduces a Deposit Return Scheme, providing an economic incentive for consumers to recycle plastic bottles.

Deposit return schemes operate in several European countries, as well as parts of Canada and the US. Committee based evidence that a deposit return scheme could help remove 700,000 plastic bottles from the environment each year. It has recommended that the Government introduces a Deposit Return Scheme, replacing plastic bottles, coffee cups and drinks bottles[5]. She has promised to extend the successful 5p levy on plastic bags to smaller shops and seek evidence on a possible change on single-use plastic containers, such as takeaway boxes.

Other initiatives include a plan to urge supermarkets to introduce ashes without any plastic packaging, where all food is sold loose, along with new research funding for ‘plastics innovations’ and aid to help developing nations deal with their plastic waste.

Iceland has become the first major retailer to commit to eliminating packaging for all its own brand products, to help end the ‘scourge’ of plastic pollution[6]. It plans to replace plastic with other packaging materials, including paper and pulp trays and paper bags, which would be recyclable through domestic waste collection systems and into new recycling facilities. Iceland has already removed plastic disposable straws from its own label range and is introducing new food ranges in early 2018, which will use paper-based rather than plastic food trays.
Public Health England (PHE) has launched the first Change4Life campaign to promote healthier snacks for children. The new campaign encourages parents to look for ‘100 calorie snacks, two a day max’ to help them purchase healthier snacks for their children.

Half of children’s sugar intake, currently around seven sugar cubes a day, comes from unhealthy snacks and sugary drinks, leading to obesity and dental decay. On average, children are consuming at least three unhealthy snacks and sugary drinks a day, with around a third consuming four or more. The overall result is that children consume three times more sugar than is recommended. Some supermarkets are supporting the campaign. Tesco will help parents – in store and online – choose affordable, healthier snacks that are 150 calories or less. Co-op will also provide tasty and healthy snacking products, making it easier for customers to make healthier choices.

PHE’s improved Change4Life ‘Food Scammer’ app also shows parents how many calories, sugar, salt and saturated fat is in their food to help make healthier choices easier. Parents can also get money-off vouchers from Change4Life to help them try healthier snack options, including malt loaf, lower-sugar fromage frais, and drinks with no added sugar.

Many of the unhealthy snacks children consume regularly are high in sugar and also typically high in calories, for example:

- an ice-cream contains around 175 calories
- a pack of crisps contains around 100 calories
- a chocolate bar contains around 100 calories
- a pastry contains around 270 calories
- a bag of sugary snacks contains around 270 calories
- a packet of crisps contains around 190 calories
- a chocolate bar contains around 200 calories
- a loaf, lower-sugar fromage frais, and drinks with no added sugar.

The ‘100 calorie snacks, two a day max’ tip applies to all snacks apart from fruit and vegetables, as children should also be encouraged to eat a variety of these to achieve their 5 A Day.

With a third of children leaving primary school overweight or obese, tackling obesity requires wider action in addition to individual efforts from parents. PHE is working with the food industry to cut 20% of sugar from the products children consume most by 2020, with work to reduce calories due to start in 2018.

Sugary drinks ban

The NHS is taking action to remove sugary drinks from its canteens, shops and vending machines during 2018.

Although almost two thirds of NHS trusts are now signed up to a voluntary scheme to reduce sales of sugary drinks to 20% or less of sales of all beverages, 91 NHS Trusts are yet to join the voluntary scheme. Hospitals and suppliers have been warned that if they do not take action to reduce sales of sugary drinks by the end of March 2018, a ban will be introduced instead.

Some NHS Trusts have gone further and have introduced their own ban on sugary drinks. As well as hospitals, 14 national suppliers have signed up to the voluntary scheme including WH Smith, Marks & Spencer, Greggs and the Royal Voluntary Service.

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Focus Future – A Regulatory Minefield?

The field of food regulation seems to be constantly developing, sometimes for the good, other times seemingly just to try the patience and resources of the food industry. However, with the impact of Brexit on the horizon, we are entering a new territory – some predict a regulatory minefield.

IFST’s Food Law Group is hosting its latest seminar on 14 March 2018 where expert speakers from the FSA and Defra will consider the potential impact of Brexit and what we might expect. Sadly, no one has a crystal ball, but predictions of the experts can perhaps help us find our way through the future potential minefield.

Most of the press attention has centred on potential policy solutions for the problems, in particular charges for disposable coffee cups and extension of the plastic bag tax. Other policy possibilities are a plan to call for evidence on tax solutions to reduce single use plastic waste, working with industry to improve plastic recycling, and plastic free aisles in supermarkets.

IFST supports the ambitions to limit plastic to the environment and the sound mantra of ‘reduce, reuse and recycle’. However, it is important that the specific solutions applied to each of these areas are science and evidence driven, and based on robust life cycle assessments that consider the environmental impacts of concern.

To confirm your attendance, please register via: https://www.ifst.org/events/ifst-annual-general-meeting-2018

DIARY DATES

13 March 2018 IFST AGM & Volunteer Meeting London
8 April 2018 IFST Spring Conference SC18, Managing Food Risk: Tools and Technologies Birmingham
2 June 2018 Sensory Science Conference 2018: Health is Wealth Birmingham

New IFST Information Statements

As part of our commitment to provide relevant and clear science-based information about food science and technology, we have released a new Information Statement on Oils and Fats. We have also updated our Information Statements on HIV/AIDS and the Food Handler and Ailments in Foods.

IFST Information Statements are peer reviewed by IFST’s Scientific Committee.

AGM just around the corner

The 54th Annual General Meeting will take place on 13 March 2018 from 11.30 at Court Room, Senate House, University of London, Malet Street, London, WCIE 7HU. All members are invited to attend. Only Members and Fellows are entitled to vote.

To confirm your attendance, please register via: https://www.ifst.org/events/ifst-annual-general-meeting-2018

Plan to confront plastics problem

Plastic bags grabbed the headlines on the recent release of the Government’s Environment Plan (A Green Future: Our 25 Year Plan to Improve the Environment) and have also generated public attention after a Blue Planet II screening at the end of 2017, which demonstrated some of the impacts of plastic on the oceans and wildlife.

The plan has called for zero ‘avoidable’ plastic by 2024 and has promised to reduce contamination of the sea and fresh water by plastic and its by-products. These are of course laudable aims, despite some criticism of the 25-year timeline to meet some targets.

Most of the press attention has centred on potential policy solutions for the problems, in particular charges for disposable coffee cups and extension of the plastic bag tax. Other policy possibilities are a plan to call for evidence on tax solutions to reduce single use plastic waste, working with industry to improve plastic recycling, and plastic free aisles in supermarkets.

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Then we can appropriately compare the environmental costs and benefits of various plastics and materials we use. In the food context, plastic also has a use as packaging to protect food products from damage and spoilage. IFST recognised the value of packaging to reduce food waste in its 2017 sustainability focused ‘Food System Framework’ document and is engaged with WRAP as a signatory to their CourtBard Agreement, to support food waste reduction. NW PDF: Framework, IFST also highlighted the need for new packaging innovations to further this aim. In addition to waste reduction, innovation should also focus on minimizing environmental impacts from the production and disposal of packaging, in terms of greenhouse gases and harm to the planet’s ecosystem.

The Government’s plan also includes goals to reduce (by 2030) per capita food waste and greenhouse gas emissions from the food supply chain by 2025. This makes it particularly relevant to view the food system environmental impacts and solutions in the broader sustainability context. The Environment Plan picks up some of these elements, for example, soil health, water efficiency and efficient farming and pesticide use. Even if they do not make the headlines, it is good to see these included. While the plan could be more comprehensive, there is crossovers with the government’s Industrial Strategy programme ‘Transforming food production: from farm to fork’ and the Green Growth Strategy IFST, for one, will continue to monitor the impact these have on progress towards a truly sustainable food system.

Also check out IFST’s top 10 facts on plastic on our website!

Sensory Science Conference 2018: Health is Wealth

IFST Spring Conference 2018 (SC18)

Managing Food Risk: Future Tools and Technologies

With the stimulating title Managing Food Risk: Future Tools and Technologies, our Spring Conference will take place on 19 April 2018 at the University of Birmingham.

Explore with us how food risk management is changing through new science and technologies and in turn how we can expect roles in the sector to change to take advantage of these technologies.

We have an excellent panel of internationally recognised speakers, with topics ranging from gut health and microbiome through to cybersecurity and the use of blockchain, 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: https://www.ifst.org/events/SC18

Health firmly on the agenda

IFST Sensory Science Group is pleased to announce that its annual one-day interactive conference – Sensory Science Conference 2018: Health is Wealth – will be held on 7 June 2018 in Birmingham. It will provide an inspiring insight into how sensory and consumer science is adapting to support the needs of the food production businesses right across the North of England.

The North of England region has a wealth of esteemed centres of learning or industry that are keen to further develop their personal qualities and knowledge and develop their career path within 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 would like to hear from members interested in helping to establish a 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 students and graduates of food science with the possibility to continue their education at one of many esteemed centres of learning or to take employment with food production businesses right across the region and further develop their career path.

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 would like to hear from members 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 via e.taylor@ifst.org.

For more information and to book your place, please visit: https://www.ifst.org/events/focus-future-regulatory-minefield

Continuing Professional Development (CPD) is how professionals maintain, improve and broaden their knowledge and develop their skills and resources of the food industry.

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 students and graduates of food science with the possibility to continue their education at one of many esteemed centres of learning or to take employment with food production businesses right across the region and further develop their career path.

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If you would like to register to attend this event, please visit: https://www.ifst.org/events/SC18

Log on and learn with IFST’s myCPD

Continuing Professional Development (CPD) is how professionals maintain, improve and broaden their knowledge and develop their personal qualities and competencies required in their working lives.

Structured CPD gives you a clear path to success within your current role and progression to future ones.

We are pleased to announce the launch of a simple to use new myCPD online system designed to help you manage your own learning and growth with ease.

It is available to registrants (full and members (Estg).
Value-added chemicals from food waste

As the availability of fossil-based resources declines, there is an impending necessity of finding alternative feedstock able to secure the production of fuels and chemicals. Exploitation of biomass as a renewable source of chemicals is an attractive possibility. Every year, large amounts of food waste are generated within the food supply chain and at the consumers use stage and hence its valorisation attracts great attention. Food waste has proven to be a valuable source of intermediates and products with promising applications in industry. These include organic acids and furans (generally used as platform chemicals to further products), polymers like bacterial cellulose, polymers like bacterial cellulose, polyhydroxyalkanoates or chitin, biosurfactants, biolubricants, or nanoparticles. This overview covers the latest trends in chemical, enzymatic and biotechnological processes on the production of these chemicals and materials from food waste.


Effect of adding seaweed flakes on the development of bioactivities in functional Camembert-type cheese

The effect of adding Palmaria palmata or Saccharina longicruris to Camembert-type cheese on both the antioxidant capacity (ORAC) and Angiotensin I-converting enzyme (ACE)-inhibitory activity has been studied with the aim of developing a functional food. The nutritional composition showed that P. palmata had the highest total protein and carbohydrate contents while S. longicruris demonstrated the highest total fibre and minerals contents. The bioactivities determined in the S. longicruris soluble extract were the highest. The feasibility of including these two seaweeds in to Camembert-type cheeses was validated through the adequate development of bioactivities during ripening supporting promising food applications.

Hell et al., 2017, doi: 10.1111/ijfs.13681

On 16 January 2018, John Bassett, IFST’s Policy and Scientific Development Director gave evidence to the House of Lords Science and Technology Select Committee inquiry into Life Sciences and Industrial Strategy.

As life sciences are broader than the medical/pharma theme currently proposed in the life sciences industrial strategy, IFST believes the impact, both economically and for the human health outcomes sought, will be greater if the scope is broadened to include microorganisms, plants and animal life as well as links to physical sciences and engineering, as part of an integrated system.

We also believe that food is a key link between these system elements and the outcomes of the strategy. With around 12% of the working population involved in food-related roles, food is important to the UK economy. Without any doubts, it also has an important impact on human health and well-being.

During the questioning, John Bassett commented: ‘The aim of the strategy is to drive economic growth with the theme of human health and medicine development but it is difficult to see how you drive it using that theme alone.’ IFST put forward particular examples of food science, which the strategy could encompass, e.g. food impacts on the gut microbiome, technologies to identify, understand and control foodborne pathogens and technologies focused on creating a sustainable food system.

In addition, we welcomed the focus on building core skills in STEM in the educational system. However, we made the comment that STEM in schools can be siloed and this is particularly evident when it comes to food science – food is typically still thought of in the context of cooking and confined to the Design and Technology curriculum.

IFST also welcomed the focus on maintaining access to international scientists and other key skills required for the strategy, post EU exit. However, the Lords were surprised to hear that in the food science area the loss of the ability to task the European Food Safety Authority to make scientific safety assessments for us will result in the need to build the capabilities of the UK Food Standards Agency, the regulator in this area.

Finally, we highlighted that data and analytics capabilities are cross-cutting and should be developed to work across numerous industries.
Members’ corner

Members

- Mohammed Alnasser MIFST, Executive Manager – Saudi Food and Drug Authority
- Irina Beale MIFST, Technical Manager – Guenther Trousdale
- Moira Byers MIFST, Self-employed
- Molly Carpenter MIFST, Night QA Manager – Greenscore Group
- Louise Cauter MIFST, Technical Manager – Green Gourmet Ltd
- Rahul Chaudhari MIFST, Technical & QA Manager – East End Foods plc
- Allison Cousins MIFST, Head of Academy Programmes – British Retail Consortium
- Gillian Dickie MIFST, International Supply Chain Auditor – Northoeast Seafoods Ltd
- Damien Fontaniere MIFST, Food Safety & Hygiene Consultant
- Alvaro Guest MIFST, Group Technical Manager – Danieli
- Jason Husse-Phillipson MIFST, Technical Team Leader – Nobel Foods
- Huiinuo Huang MIFST, Global Meat Scientist Applications – ROHA USA LLC
- Panteliana Ioannou MIFST, Food Scientist – MediCom Labs
- Suresh Jones MIFST, Co-founder, Nutribloc
- Ley Lashbrook MIFST, Technical Manager – Zerba Delicacies
- Daryl Littlejohns MIFST, Director – Littlejohns Food and Safety Ltd
- Lok-Yin Mok MIFST, Regulatory Compliance Manager – Premier Foods
- Natasha Medhurst MIFST, Regulatory Affairs – McCormick (UK) Ltd
- Gintare Narusveicute MIFST, NFIP Technologist – 2 Sisters Food Group
- Oluwakemi Odumeku MIFST, Teaching Assistant – Royal Agricultural University
- Rebecca Shaw MIFST, NFIP Manager – TasteConnection Ltd
- Nicola Stanley MIFST, Independent Sensory & Consumer Insight Consultant
- Debbie Sullivan MIFST, Independent Consultant, Trainer and Auditor – QMS Solutions
- Antonio Sulle MIFST, Scientist (Project Leader) – DIAGEO
- Alvin Joseph Tom MIFST, Certification Officer – Food – EXOVA BMTTRAIDE
- Jeanne Malene Tonon MIFST, Food Technologist
- Suzanne Wood MIFST, Inspector – Soil Association Ltd
- Faraad Amirзадollahian FIFST, Associate Professor in Nutrition – Liverpool Hope University
- Geoff Collins FIFST, Marketing and Innovation Director – Ultimate Sports Nutrition
- Joseph Hart FIFST, VP Science and Technology – Hart of the Matter
- Louise Hewson FIFST, SCPI Senior Scientist – PepsiCo
- Tina Jeary FIFST, Technical Development Director – Albert Bartlett
- Alec Kyrilakis FIFST, Head of Product Safety – Sainsbury’s Supermarkets Ltd
- Brian Mullin FIFST, Founder and Managing Director – Salutary Limited
- Jessie Plumpton FIFST, Head of Food, Technical and Process Improvement – Tails
- Rabin Sapkota FIFST, Technical Manager – Kerry Foods
- Madeleine Wilson FIFST, Fruit & Floral Category Technical Manager – Sainsbury’s Supermarkets Ltd
- Finnanna Wilson FIFST, Food Safety Manager – Sainsbury’s Supermarkets Ltd
- Kyriacos Mavridis FIFST, Health, Safety and Environment Manager – Sainsbury’s Supermarkets Ltd
- Hongdeng Wu FIFST, Quality Assurance Manager – Tesco
- Wei Xin Ng CSci, R&D Team Leader – BCH (Rochdale Ltd)
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There have been many twists and turns on the rollercoaster they call Brexit. Those of us who work in regulatory affairs tend to appreciate stability and certainty, so the bumpy ride we’ve experienced over the last 18 months has been particularly uncomfortable! With just over a year to go until we leave the EU, you would have thought plans for our new regulatory regime would have begun to take shape by now.

Yet whilst there has been much debate and scenario planning for the UK’s exit from the EU, the reality is that firm plans are still proving elusive due to a lack of clarity on the political front. The Government has made clear its intention is to formally commit to Brexit at 23:00 GMT on Friday 29 March 2019, so at least we have relative certainty over the time and date of departure. This means that the majority of the enormous amount of work that needs to be done to ensure that there are no so-called ‘inoperabilities’ on the first day of Brexit, must be completed during 2018. Nowhere will the enormity of the task be felt more than with those civil servants in departments that interact with the food and drink industry, who must be challenging at the bit for officials to put pen to paper.

The production, processing, distribution, retail, packaging and labelling of food and drink is governed by a wealth of laws, regulations, codes of practice and guidance, the majority of which are harmonised across the EU. All of that needs to be ‘lifted and shifted’ into UK law and in some cases new provisions made, if we essentially become a ‘third country’ to the EU. This latter area is incredibly important when it comes to import and export considerations, health certificates etc. and is a major area of concern for many food and drink businesses. The issue of the Irish border with the commonising and fusing of ingredients and products across it, which has been widely debated, brings many of these topics into sharp relief, and will be an essential early indicator of whether provisions have been adequately made.

The safety and authenticity of our products remains paramount for industry and continues to be the top priority for the Food and Drink Federation. Common regulatory and legal requirements informed by sound science and evidence allow companies to do business and trade on a level playing field, whilst also protecting consumers. But EU regulation can also create barriers and burdens that limit the ability of businesses to innovate and make improvements possible. Despite this, we do not expect much discussion around these potential improvements until we can ensure the continuity of operations that we so need.

Indeed, the issue of whether the UK should continue to follow the regulatory lead of the EU is a hot topic. Regulatory alignment with the EU has the benefit of ensuring fewer non-tariff barriers to trade with our nearest neighbours. However, many business operators, especially those who have little movement of raw materials or finished goods across national borders, argue that divergence of regulations could be highly beneficial when it comes to encouraging innovation. Somewhere in the mix are considerations, such as regulatory equivalence, mutual recognition and outcome equivalence. It is likely that all of those terms will be given a much clearer definition than is currently the case, and once day one ‘post-Brexit issues’ are settled, it is possible to envisage that discussions on a case-by-case basis on different regulatory topics will begin with Government officials. Where previously regulatory convergence between the UK and the EU have been of primary consideration, it is possible we’ll see future trade agreements with countries, such as the US, Canada, Australia and New Zealand, drive discussions.

For many stakeholders, the key in the days and weeks to come will be to allow regulation to be driven by evidence, something the UK has a proud heritage of upholding (though some might argue that there have been some notable exceptions!). Many have talked about a desire to simplify regulations and Brexit providing an opportunity to deliver this. Government has indicated that there will not be a ‘delegatisation’ agenda but one of ‘smarter’ regulation. This is an ambition that is difficult to argue against, but in practice is likely to be tough to achieve without much brain power and energy.

We know that getting this right is key for business continuity and profitability, and most importantly ensuring continued consumer trust in the food chain, and therefore it is something that everyone in the regulatory affairs arena will agree is of the highest priority.

Helen Munday, Chief Scientific Officer, Food and Drink Federation, looks at some of the regulatory issues the UK food and drink industry faces as it embarks on the road to Brexit.
Food, larvae-ly food...

Introduction
Inadequate protein intake and protein energy malnutrition affects 1 billion people worldwide. The global population is projected to reach 9.6 billion by 2050 leading to a global food demand increase of up to 70% compared with our current food requirements. Conventional sources of protein will not be sufficient for the global human population and alternative sources, such as vegetables, algae, microorganisms, insects and cell cultured meat will be required. Insects, classified in the arthropod phylum alongside crustaceans, are invertebrates with a chitinous exoskeleton and a jointed body. Proteins have been recorded to be the dominant protein source in the diet. Protein quality is not defined by one measure, instead overall protein content, indispensable amino acid content and digestibility are all required to evaluate a protein source. Protein contents of insects have been reported to be between 35 and 62%[1] making many species of insects greater in protein content than beans, lentils and soybeans. In a recent study, comparisons on a dry matter basis showed that the average protein content of edible insects is generally comparable in density to that of conventional high quality animal protein[2].

Mean protein content was however found to vary between insect order from 40% for termites (order Isoptera) to 64% for cockroaches (order Blattodea) as well as within species belonging to the same order. The variation in protein content, which will also be reflected in amino acid content and digestibility, is a result of differences in order, species, diet, sex, life stage and habitat of the insect. In addition, factors such as analysis method, insect processing to remove inedible parts and the presence of a chitin rich exoskeleton will all impact on the protein quality assessment of insects.

Amino acids, the building blocks of protein, are characterised as dispensable and indispensable. Indispensable amino acids cannot be synthesised by the body and therefore must be provided in the diet. Fulfilling the requirement for each of the nine indispensable amino acids - leucine, isoleucine, valine, lysine, threonine, tryptophan, methionine, phenylalanine and histidine – defined by the WHO/FAO/UNU 2002 report is used to define protein quality. Indispensable amino acid content of edible insects has been found to vary, due to factors outlined above. Some studies have found insects to be deficient in tryptophan, methionine and/or lysine, however in one study, insects from orders Coleoptera (Beetles), Hymenoptera (Bee), Lepidoptera (butterflies) and Orthoptera (grasshoppers, locusts, crickets) on average meet or exceed current indispensable amino acids contents for adults with these contents being comparable to beef, eggs, milk and soy[3].

Finally, protein digestibility must be considered as it dictates the availability of amino acids to the body after consumption. Based on an enzymatic in-vitro assay, the protein digestibility of a selection of edible Mexican insects has been reported to range between 77 and 98%[4]. This is higher than for some vegetable based proteins and, for some species, only slightly lower than values reported for animal protein sources (egg 95%, beef 98%, casein 99%)[5].

Overall results from studies are promising in terms of protein composition, although there is a need for further studies to gain a more comprehensive nutritional assessment of insects. The evidence does suggest that some species of edible insects are relatively high in protein, have contents comparable to animal derived and soy protein on a dry matter basis, provide an adequate indispensable amino acids content and can be classified as highly digestible. So why are we not eating more insects?

Insect consumption
Disgust? Distaste? A history of trying to keep insects out of food products? Yes! Several studies conducted in developed, non-insect consuming countries found a reluctance to consume due to their association with nature, animalness, appearance and a certain degree of food neophobia as insects have never played a substantial role in the diet. However, honey and Carmine E120 (a red food dye extracted from the female cochineal insect) have been widely accepted and we are starting to see an increase in interest in consumption of insect containing food products from the novelty ‘bush-tucker trial’ lollipop stick to insect flour, energy bars, pasta and sauces.

In Switzerland, this offering has been extended to insect burger and balls all made with mealworms, because as of May 2017, Switzerland became the first European country to authorise the sale of food items containing three types of insects: crickets, grasshoppers and mealworms.

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Dr Jo Gould of the University of Nottingham discusses the potential for incorporating insect proteins into foods as both nutritional and functional ingredients.

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meals and found that all photos of insects were rated higher than chocolate coated mousse or the wobbly egg custard traditionally found as dessert foods. The advantage of using insects as a food ingredient may, however, be limited due to a lack of consumer acceptance. In order to create this continuous network, protein dispersions are processed (often heated) to allow for an increased amount of intermolecular interactions. Heated aquatic insects extract, a gel-like product from five insect species (yellow mealworm, superworm, lesser mealworm, house cricket and dubia cockroach) were found to form gels, with properties comparable to those formed from conventional food proteins. Further rheological investigations showed that gel strengths were affected by the species and growth stage of the insect\[6\], indicating not only a need to further understand these differences but also to point to the potential to use different insect ingredients to create customised product textures. Emulsions (mixtures of two immiscible liquids e.g. water and oil) require a third ingredient to allow for the formation of stable droplets of one liquid dispersed in the other. However, insect proteins appear to be positive in the classification of these third ingredient can be protein. A gel, classically defined as the product of the conversion of a fluid to a solid by the formation of a continuous network, possesses a degree of elasticity, which is often quantified rheologically. Formation of a suitable protein gel structure, which is affected by the protein type, concentration and gelation conditions, plays an important role in food texture perception and stability. Water and oil absorption of these flours was found to be higher than 250 and 350%, respectively. However, the absorption of the flours was very low, more likely less, due to the mixed composition of the flour, particularly the presence of fat, which acts as an anti-foaming agent. More recently, studies have focused on understanding the properties of isolated proteins from insects rather than flours. It is often hypothesised, as it was for dairy and more recently vegetable protein, that the inclusion of insect proteins in different foods will be driven by the added functionality they can bring to a product formulation and for this it is necessary to understand the physico-chemical properties of the protein.

**Functional properties of insect protein**

The ability to generate gel, emulsion and foam dispersions are created added value for a food ingredient and hence has been a topic of study for insect protein. Preliminary investigations have shown varying results as a consequence of the use of different species and insect processing methods, but some promising findings have been reported. The formation and stability of an emulsion is required in food products, such as salad dressings, sauces, processed meat products, coffee whiteners and frozen desserts. An aqueous extraction precipitate from edible house crickets with a protein content of 67% was found to have good emulsifying capacity and stability higher than the non-water soluble fraction and hexane soluble fraction from the same flour\[7\]. A recent study at the University of Nottingham provided further validation of the emulsifying properties of insect protein by demonstrating that protein isolated from mealworm larvae stabilized oil-in-water emulsions for a storage period of two months with no change in stability following the addition of salt or temperature variation (-20°C to 80°C, indicating a wide range of potential food product applications. Comparisons with whey protein also found that a smaller quantity of mealworm larvae protein was required to generate the same emulsion microstructure\[8\]. Finally, foams (gas bubbles in a continuous liquid or solid phase forming immiscible phases of two or more materials, such as cakes, meringues, ice cream), i.e. air-in-water systems, require a third ingredient to allow for the formation of stable foams. The water soluble protein fraction from superworms produced a stable foam, whereas in the same study, extracts from yellow mealworm, lesser mealworm, house cricket and dubia cockroaches were unable to form foams. However, the results will have been affected by the relatively low protein concentration and the presence of oil in the extract. In comparison, unpublished data from the University of Nottingham indicates that in the other two insect species, the microstructure of one such foam is shown in Figure 3, with foams of higher capacity and stability being comparable to that of egg white protein. These findings are supported by published surface tension data showing the ability of protein extracts isolated from mealworm larvae to adsorb at a gas bubble interface thus increasing the surface tension and creating an interface film. Values of surface tension of mealworm larvae proteins were comparable to those of other commonly used proteins, and interestingly, proteins extracted from mealworm larvae that underwent a thermo-mechanical pre-treatment allowed for a greater reduction in surface tension, which may provide higher foaming functionality\[9\].

**Conclusions**

It is clear that there is still a need for more information and understanding of the physico-chemical properties and indeed the nutritional composition of insects and insect extracts to allow for integration of these ingredients into food products. Interestingly, in both aspects, results vary between insects and understanding why these differences exist and how they could be exploited in food products is a challenging and exciting area opening up to food scientists globally. Although the journey to the supermarket shelf is only just starting, edible insect protein has the potential to be a future food ingredient providing nutrition and functionality in a more sustainable manner than conventional sources of protein. 

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**References and article available online at FSTJOURNAL.org/features/32-1/insect-ingredients**

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Insects as food and feed

Introduction
Eating insects (entomophagy) is a bizarre concept for many of us. However, it is normal for approximately two billion people, from 3,000 ethnic groups in 113 countries, for whom food includes over 2,000 insect species. Even in the UK we unknowingly eat around half a kilo of insects a year. All processed foods include insects; either deliberately added as carmine red food colouring €125, made from cochineal bugs, or accidentally harvested with plants because they are so abundant in nature that it is impossible to remove them all.

These insect fragments make it into coffee, peanut butter, chocolate and much more. It is applied to insects, the potential for food and feed markets and the challenges they face. The UN is hunting insects as a vital source of food and feed to secure global food security due to their nutritional profile[5]. Although the diversity of insect species makes generalisations difficult, several insect species were shown to have equivalent nutritional value to many meat products. For example the house cricket (Acheta domestica) has comparable protein content and digestibility to beef and egg providing all 9 essential amino acids; it is also a richer source of polyunsaturated fats than beef, delivered in the ideal ratio of 3:1 omega-6 to omega-3[6].

Nutrition considers the challenge of feeding 9.6 billion people by 2050 and responding to the expected 57% increased demand for high quality animal protein over the same period. Furthermore, 78% of all agricultural land is currently used in livestock production (grazing = 68%, cropland for animal feed = 10%) with 80% of new croplands replacing forests[2]. These challenges must be met while facing soil depletion, spreading oceanic dead zones and climate change (animal agriculture is one of the top three emitters of greenhouse gases, producing more than the global transport system). At the same time, the remaining wild spaces and their associated biodiversity and ecosystem services, which maintain Earth’s capacity to support life, must be preserved.

Edible insects: the yuck factor
The biggest challenge entomophagy faces in the western world is the ‘yuck factor’: this repulsion is a learnt psychological aversion, which can easily be overcome by getting people to taste a delicious, highly nutritious food, which happens to be made using crickets. The positive taste experience rapidly overwhelms the immediate knee jerk resistance.

Forty years ago the thought of eating raw fish turned the stomachs of most westerners, but today there are packs of sushi in every garage forecourt and a YO! Sushi on most high streets.

The majority of the effort to bring insect protein to our stomachs of most westerners, but today there are packs of sushi in every garage forecourt and a YO! Sushi on most high streets. Soaring soybean and fish meal prices mean that the search is on for alternative protein sources for animal feed. Additionally, the incredible diversity of insect species, estimated at over one million, offers the tantalising possibility that insects adapted to regional conditions could be farmed locally, reducing the need for international transport of animal feeds, increasing national and regional protein security and counteracting the negative environmental impact of some feed sources, for example Chilean fishmeal or Brazilian soybeans grown in what used to be the Amazon Rainforest.

Global food chain
Incorporating insects into the global food chain provides an opportunity to address the huge challenge of feeding 9.6 billion people by 2050 and responding to the expected 57% increased demand for high quality animal protein over the same period. Furthermore, 78% of all agricultural land is currently used in livestock production (grazing = 68%, cropland for animal feed = 10%) with 80% of new croplands replacing forests.

These solutions include eating less meat, transitioning from inefficient ruminants to more efficient poultry and swine, and developing new and emerging technologies including cultured meats and protein from algae, fungal and insect origins.

In comparison to traditional agriculture, insect farming has a tiny footprint: kilo-to-kilo edible insect protein requires 500 times less water, 12 times less feed, and 10 times less land than beef, while producing 69% times less greenhouse gases[4].

Traditional livestock production has been subjected to selection and improvement for generations, with a recent specific drive for feed conversion efficiency resulting in massive improvements in productivity: under optimal conditions a breeder in 1985 could reach 1.40kg in 35 days using 3.22 kg of feed, but by 2000, breeders could reach 2.44kg on 3.68 kg of feed[2].

The toolkit developed in traditional agriculture of breeding, genetics, husbandry, nutrition and veterinary science is applied to insects, the potential for rapid improvement, from an

Douglas Moore of Montefield Nutrition considers the potential for developing insects as an alternative source of protein for human food and animal feed.

Adult banded crickets (Gryllodes sigillatus) searching for a suitable egg laying site.

Mealworms are the larval stage of a beetle, Tenebrio molitor, and are suitable for use in both food and feed.
THE BLACK CRICKET
Gryllus bimaculatus

Multiple species of cricket are commercially reared as food, with over 20,000 tonnes of crickets, or cricket powder, being produced annually. Both Gryllus and full grown crickets are sold in the market. The black cricket is one of the favoured species due to its superior taste. They have a high reproductive rate and short life cycle. Crickets are capable of eating a wide range of containers from cardboard to egg boxes that are available in the market. A full life cycle can take as little as 35 days and an adult cricket can produce up to 2000 eggs during their 45-day lives. The crickets are reared in a range of containers from plastic boxes to shipping containers, fed on the cheapest available diet, which is often chicken feed. Adding vertical structures, e.g., bamboo internodes or cardboard egg boxes, increases the number of insects that can be reared in any given area. Rearing crickets in the wild is economically viable and is an excellent way to produce food with minimal impact on the environment.

The black cricket, Gryllus bimaculatus, is known for its high protein content and is a popular choice for insect-based diets. It is estimated that black crickets contain 60% protein and 21% fat. This makes them an excellent source of protein for both entomophagy and nutrition research.

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THE BLACKSoldier FLY
Hermetia illucens

The larvae of the black soldier fly (Hermetia illucens) are nutritional consumers, as they are ideal for use in aquaculture as high quality protein and fats for livestock feed. These insects are often known as ‘kitchen ornaments’ in order to recapture and recycle the waste. However, exploitation of these species onto the market is hindered by the fact that black soldier fly larvae require relatively small breeding populations to be maintained. The larvae have a prodigious growth rate and a voracious appetite - they can feed on most organic material including vegetable matter, meat and animal manures, and can reach harvest compositions of up to 45% protein and 35% fat. Black soldier flies are the only species of insect approved for use in animal feed in the USA (fish and poultry) and, are one of the species allowed in aquaculture in the EU.

The black soldier fly larvae are large maggots that grow from a 0.05mg egg to 33mm long. 0.5g larvae in as little as two weeks, at which point they are harvested. A full life cycle can take as little as 35 days and an adult female will lay around 400 eggs. Even relatively small breeding populations can be maintained. The larvae have a prodigious growth rate and a voracious appetite - they can feed on most organic material including vegetable matter, meat and animal manures, and can reach harvest compositions of up to 45% protein and 35% fat. Black soldier flies are the only species of insect approved for use in animal feed in the USA (fish and poultry) and are one of the species allowed in aquaculture in the EU.

As early as 1995 it was suggested that flies be used to produce animal feeds. H. illucens larvae are large maggots that grow from a 0.05mg egg to 33mm long. 0.5g larvae in as little as two weeks, at which point they are harvested. A full life cycle can take as little as 35 days and an adult female will lay around 400 eggs. Even relatively small breeding populations can be maintained. The larvae have a prodigious growth rate and a voracious appetite - they can feed on most organic material including vegetable matter, meat and animal manures, and can reach harvest compositions of up to 45% protein and 35% fat. Black soldier flies are the only species of insect approved for use in animal feed in the USA (fish and poultry) and are one of the species allowed in aquaculture in the EU.
New ingredients for fishmeal

James Wright of the Global Aquaculture Alliance explains how the aquaculture industry is beginning to address the fishmeal feed bottleneck with microalgae, insects and single-cell organisms.

Expected to reach nearly 10 billion people by mid-century, the growing global population requires efficient means of protein production. Consumer demand for animal protein could increase by as much as 80% by 2050, according to some estimates, a trend fuelled by population growth and increasing middle-class spending power. With suitable land for terrestrial livestock production at a premium, the food systems of the future must turn to the water.

Aquaculture, one of the world’s fastest-growing industries, already accounts for roughly 35% of the global fishmeal and fish oil production. Consumer demand for these ingredients is currently small in scale, however, the aquaculture industry has begun sourcing limited quantities of these ingredients blended into innovative new aquafeed formulations, tailored to species based on documented nutritional requirements.

In fact, aquaculture’s usage of the global fishmeal and fish oil supply has increased from roughly 10% in 1980 to nearly 75% in 2010, according to IFFO, which forecasts global fishmeal production to increase from 6 million metric tons (MT) in 2012 to up to 7.75 million MT in 2022, mainly due to increasing production to increase from 6 million metric tons (MT) in 2012 to up to 7.75 million MT in 2022, mainly due to increasing global fishmeal and fish oil demand for alternative ingredients while a growing number of major feed companies are continuously striving to overcome its primary limiting factor: finite supplies of fishmeal and fish oil – or, in other words, the fish that farmed fish eat (anchovy, sardines, menhaden and sandeel, to name but a few). Global fishmeal and fish oil production have remained steady in recent years at 5 million metric tons (MT) of fishmeal and 3 million MT of fish oil annually, according to IFFO, The Marine Ingredients Organisation. But aquaculture’s demand for these ingredients is growing steadily.

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Aquaculture producers have successfully utilised plant-based ingredients, like soy and soya-based proteins, for many years, but more recently their search for fishmeal and fish oil replacements has veered towards microalgae, single-cell organisms and insects.

While production of emerging fishmeal and fish oil alternative ingredients is currently small in scale, the aquaculture industry has begun sourcing limited quantities of these ingredients blended into innovative new aquafeed formulations, tailored to species based on documented nutritional requirements. Innovation in the sector has economic benefits as well, major feed companies are investing in new technologies for alternative ingredients while a growing number of outside investors, a sector traditionally wary of aquaculture ventures, are taking notice of the disruptive technologies and the vast opportunities that new businesses represent.

Making moves with microalgae

Founded in 2003 in California’s Silicon Valley, Solazyme initially set out to create a renewable fuel source by fermenting algae, a plentiful, inexpensive and sustainable resource that grows quickly and in almost any environment. The company ultimately switched its focus from biofuels to food, and its name to TerraVia (which is now a part of Corbion N.V., a Netherlands-based biotechnology company, following a late 2017 acquisition). In conjuction with Bunge Oils, the company produces microalgae at its R&D laboratories in South San Francisco – and at a much larger scale at a sugarcane farm in Brazil, which boasts some of the world’s largest aerobic fermenters. The facility runs off the steam from the sugarcane mill, converting sugars into oils and into an algae biomass that’s marketed as AlgaPrime.

The product is billed as a traceable, sustainable, high-quality alternative to fish oil, as it produces the long-chain omega-3 fatty acid DHA (docosahexaenoic acid) at levels of 28% or more. According to Walt Rakitsky, senior VP of emerging business, there is a well-known deficiency of long-chain omega-3s in both humans and animals need a lot more than is available. AlgaPrime is not yet to replace fishmeal, but to serve as a complementary ingredient in nutritious aquafeeds, particularly for species that need a high omega-3 content, like farmed salmon.

The Chilean salmon producer Ventisqueros launched a Pacific cohort salmon product in 2017, touting a forage fish dependency ratio of just 0.5 kilograms. The forage fish dependency ratio is a metric that is analogous to the ‘fish-in-fish-out’ ratio, which measures the kilograms of wild fish required to produce 1 kilogram of farmed fish. By using an aquafeed product produced by SolMar, with AlgaPrime as a major ingredient, the company claimed its SilverIsle™...
Salmon made Ventisqueros the aquaculture industry’s ‘first net salmon producer,’ creating more fish than it uses in feed.

Fermentation of single-cell organisms

California-based biotechnology company Calysta started making waves in 2015, when it announced the launch of a groundbreaking animal feed product that converts microorganisms – methanotrophs that feed on industrial methane – into a nutritious feed protein. Its methanotroph is a non-GMO, nutritious feed protein. Its industrial methane – into a high-grade source of protein, the company conducted a feed trial with farmed shrimp at Auburn University (Auburn, Ala., USA) that proved their worth in seafood’s nutritional impacts of new feed formulations. To drive innovation in the aquafeed sector, and to find viable alternatives to fishmeal – traditionally the main ingredient in aquaculture feeds – the fish farming industry is clearly embracing the development of novel proteins derived from microalgae, single-cell organisms and insects. With limits on global forage fisheries – traditionally the main ingredient in aquaculture feeds – the fish farming industry is clearly embracing the development of novel proteins derived from microalgae, single-cell organisms and insects.

Calysta CEO Alan Shaw describes FeedKind® as a high-grade source of protein, approximately 70%, that can be fed to both aquatic and terrestrial livestock, even household pets. While the farmed salmon sector is a particularly attractive market for the product, the company conducted a feed trial with farmed shrimp at Auburn University (Auburn, Ala., USA) that showed that shrimp fed a diet including FeedKind® had equivalent or higher survival and growth when compared to shrimp fed a standard fishmeal-based diet. Calysta’s founder, Josh Silverman, sees the company’s big advantage as the ability to use methane as a feedstock because methane is the cheapest source of carbon on the planet. He claims that the low cost of methane will allow FeedKind® to be cost-competitive with natural fish oil. FeedKind, another biotechnology startup founded by Larry Feinberg, is also employing the power of microorganisms to create alternative proteins for aquaculture. KnipBio’s R&D laboratory in Lowell, Mass., is ramping up production of an ingredient derived from a single-cell organism (Methylobacterium extorquens) that in nature is a leaf symbiont that grows on plant leaves.

The final product, a pink-coloured powder, is a dried and processed form of the microbial biomass produced via a fermentation process using natural gas. Certain forms of KnipBio’s Maul can contain astaxanthin carotenoids, which are important to aquaculture for the pink flesh colouring added to farmed salmon, trout and shrimp. Feinberg claims that the company can dial in the amino acid composition and the carotenoid expression level. He hopes that perceptions of biotechnology will evolve as products like his, and Calysta’s, prove their worth in seafood's market introduction facility' in Tessside, United Kingdom.

In 2017 the European Commission (EC) amended Regulations 999/2001 and 142/2011 allowing insect-based feeds and food ingredients after more than two decades, opening the door for a handful of small insect meal manufacturers to penetrate the aquafeed market. One contender is Agriprotein, which operates a waste supply chain and black soldier fly egg and juvenile larvae production facility in Cape Town, South Africa, manufacturing dehydrated larva it markets as MagMeal®. The company engages in what it calls ‘nutrient recycling,’ taking in abundant food waste – a global figure that reaches 1.3 billion metric tons annually, according to the FAO – and processes this waste to feed. Agriprotein dries and processes the larvae into a nutritious feed ingredient. The company has received six EU-backed licenses for agreements for use in aquafood and pet food at Ynsite, its 3,000-square-meter demonstration facility near the city of Dole, France. Ynsect aims to build a commercial production facility that could produce more than 20,000 MT. Canada’s Enterra Feed Corp. has a black soldier fly production and processing plant with the capacity to transform 36,000 tons of food waste each year into 2,500 tons of protein and oil and 3,000 tons of organic fertiliser (the larvae ‘frazil’, or manure, that is loaded with beneficial microbes).

It is a promising start for insect meal, but still a drop in the global animal feed industry bucket, an estimated $400 billion market, according to the International Feed Industry Federation.
on creating alternatives for fish oil. But while the replacement of fishmeal and fish oil in aquafeeds with ingredients from terrestrial aquaculture has been a win for conservation efforts, diets containing less fishmeal and fish oil have inevitably impacted the nutritional profile of farmed fish. Researchers at the University of Stirling (Scotland) announced in early 2017 that Scottish farmed salmon sampled in 2015 had roughly half the amount of omega-3 fatty acids of fish flesh sampled in 2006. Dr Matthew Sprague explained that as the aquaculture industry continues to grow, the finite amount of fish oil is being spread thinner and thinner and combined with vegetable oils in the feeds of fish, resulting in a decrease in the levels of omega-3s in farmed salmon. The work discovered an average of 1.5 grams of EPA-DHA per 100 grams of flesh, while in 2006 the standard recommended portion of 130 grams contained 3.5 grams of EPA-DHA. However, the researchers insisted that farmed salmon remains one of consumers’ best sources of omega-3 fatty acids and delivers the second-highest EPA (eicosapentaenoic acid)-plus-DHA levels of any fish species, behind only mackerel.

Conclusions

Aquaculture is one of the world’s fastest-growing industries and one of the most efficient means of producing animal proteins for human consumption. Farmed aquatic species raised on aquafeeds retain more protein and energy from their feed sources than do farmed cattle, pigs and chickens, while in many cases boasting a higher meat yield and lower feed conversion ratio. For the industry to capitalise on its massive opportunities for expansion, it must embrace new technologies and novel feed proteins like microalgae, single-cell organisms and insect meals to supplement finite global supplies of fishmeal and fish oil. The aquaculture industry is proving itself to be highly adaptable and up to the challenge of identifying alternatives to fishmeal and fish oil. This type of innovation will be critical to provide enough food with adequate nutrition to feed a growing human population.

The aquaculture industry is proving itself to be highly adaptable and up to the challenge of identifying alternatives to fishmeal and fish oil.
Meat and dairy products are delicious, nutritious foods that have enormous cultural importance and provide 20% of the calories and one third of the protein consumed by humans. Unfortunately, animals are a very inefficient way to make delicious foods. Only 3% of the calories and proteins fed to cows make it into the human diet, and only 9% of those fed to pigs. The majority of the rest of the raw materials end up as waste products, which include air pollutants that constitute 15-18% of the world’s anthropogenic greenhouse gas emissions. This is on a par with the entire transportation sector. It is hard to imagine another industry that would accept 3% efficiency in its production system, let alone an industry of this scale and importance.

Supporting the global desire for meat and dairy products takes an inordinate amount of the world’s resources. In addition, over that timeframe a 75% increase by volume in meat production (Figure 1) and a 60% increase in dairy production is expected. This is equivalent to the addition of 425 million cows, 200 million pigs and 17 billion chickens to the current numbers. It is unrealistic to think that enough resources can be found to scale up the current production system to meet this demand.

The challenge is how to produce the delicious, nutritious meat and dairy products that people demand in a way that will allow us to continue enjoying the planet on which we live. There is a clear need to rethink the entire system. In our current approach, an animal is used as a technology to transform the proteins, fats and carbohydrates present in a form that we do not particularly want to eat (grass, corn, soy etc.) into a second form that we find delicious (meat, milk etc.). The question that we asked at Impossible Foods was whether you could produce a composite material of protein, fat and other nutrients, directly from plants, that would recreate the look, touch, taste, aroma and chew of meat. The goal is a product that handles and tastes like meat in the raw state as well as during, and after, cooking.

In order to replicate the performance of meat, Impossible Foods proceeded to reverse engineer the material to determine which molecules and structure were critical to quality. These include the rheological transitions that occur whilst meat cooks, as well as the sights and sounds of the meat sizzling on the grill. They also include the characteristic aromas that develop during cooking, which prime the brain to expect a delicious meal. Importantly, the chef wants to be able to create different dishes from the same meat, highlighting different flavour profiles in the dish.

This approach led to a number of important insights,

**Chris Davis of US-based Impossible Foods describes how the company developed a burger that tastes like meat but is made entirely from plants.**
The current Impossible Burger has slightly more protein, no cholesterol and essentially the same calories as 80/20 ground beef.

Table 1. Comparison of the environmental impact and resources required to create a 1/4 lb burger. Numbers for beef are extracted from published studies (7-9). Numbers for Impossible Burger are taken from an Impossible Foods LCA, as reviewed by Quantis.

<table>
<thead>
<tr>
<th>Environmental Impact</th>
<th>Beef Burger</th>
<th>Impossible Burger</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ equivalent emissions (Kg)</td>
<td>2.3-7.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Water required (liters)</td>
<td>20.8-23.5</td>
<td>6.0</td>
</tr>
<tr>
<td>Land required (Square feet)</td>
<td>83-254</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The red colour of leghemoglobin is highly abundant in the nodules of soybeans during nitrogen fixation, the red colour of the dissected nodule is due to the presence of leghemoglobin (Figure 2).

Despite its abundance, accessing the leghemoglobin in soy nodules through traditional agronomic harvesting techniques was rejected for both mechanical and environmental reasons. We found that the leghemoglobin from the root nodules of soybeans not only has the same structure, but performs the same flavour chemistry as myoglobin. Leghemoglobin is highly efficient method to make Pichia pastoris was rejected for both mechanical and environmental reasons. We found that the leghemoglobin from the root nodules of soybeans not only has the same structure, but performs the same flavour chemistry as myoglobin. Leghemoglobin is highly abundant in the nodules of soybeans during nitrogen fixation, the red colour of the dissected nodule is due to the presence of leghemoglobin (Figure 2).

The current Impossible Burger has slightly more protein, no cholesterol and essentially the same calories as 80/20 ground beef. The other ingredients required to create the Impossible Burger are readily available commodity products: wheat and potato proteins to provide the chew and nutrition; coconut oil to provide the sizzle and mouthfeel; leghemoglobin, other nutrients and Maillard components to provide the flavour. This simple set of ingredients combined with standard manufacturing processes allows large scale, cost effective production of the raw Impossible Burger. This is then sold to the chef for use in the recipe of their choice. As the flavour compounds are generated whilst the meat cooks, it allows the chef to modulate the taste by changing cooking conditions, exactly as you would with the animal product. Indeed, the underlying chemistry is identical.

The current Impossible Burger has slightly more protein, no cholesterol and essentially the same calories as 80/20 ground beef. In future iterations of the Impossible Burger, the ingredients and processes will be changed to make the product more delicious, increase the nutritional value of the food and decrease its environmental footprint. In order to fill the anticipated production ramp for meat (Figures 1), we will need better supplies of neutral tasting functional proteins from sustainable sources.

To measure the environmental impact associated with the production of the Impossible Burger, we performed a rigorous lifecycle analysis that we could then compare with the incumbent product, ground beef. The results are robust estimates that can be compared against the range of impacts associated with different beef production systems. As can be seen in Table 1, production of the Impossible Burger is significantly more efficient and sustainable than producing an equivalent burger using conventional animal technology.

These benefits are significant. For example, if only 10% of the annual US ground beef consumption (861 million pounds), was exchanged for the Impossible Burger, it would free up the land area equivalent to approximately 200 San Franciscos, and the equivalent fresh water of almost three billion showers. We have also leveraged our impact numbers to inform models of dietary adoption at a national scale, which demonstrate potential for enormous environmental savings.

Further, the lifecycle analysis provides guidance that allows optimisation of the Impossible Burger to reduce the environmental impact of production whilst we continue to improve the organoleptic and nutritional properties of the product. The Impossible Burger is the first product to emerge from this new approach, which provides a technology platform for the future of food. The same technology is being applied to other animal products, as we look for sustainable ways to make the food needed to feed the nine billion, who deserve a delicious, nutritious diet that does not destroy the Earth. As the scientific method is applied to the production of meat and dairy products from sustainable sources, we anticipate a future where the quality of food increases whilst freeing up resources for biodiverse landscapes that actively reduce the greenhouse gases in the atmosphere.
The future of food will be algae based and when algae goes from non-food to food we will live on a healthier, cleaner and thriving planet.

References and article available online at

References and article available online at

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Introduction
The quality of processed foods depends not only on the initial status of the raw materials but also on the changes occurring during processing and subsequent storage that may cause losses and decreased bioavailability.

Food quality, defined as ‘the ensemble of properties which differentiate individual units and influence the degree of acceptability of the food by the consumer or user’, in general declines post-harvesting or processing (with the notable exceptions of maturation and ageing).

Therefore, for each food product, there is a finite length of time after production for which it will retain an acceptable level of quality, defined as its ‘shelf-life’, under specific conditions of handling and storage. Although this term is frequently used due to its practical applicability, there is not a uniformly established definition of shelf life. The exact definition and the criteria for estimating it depend on specific commodities and on the definition intended use (i.e. for regulatory vs. marketing purposes). According to Regulation (EU) No 1169/2011, ‘date of minimum durability of a food means the date until which the food retains its specific properties when properly stored’.

The inconsistency of the nomenclature and current open dating practices worldwide can cause confusion and lead to excessive food waste.

The problem that arises is two-fold: on one hand, ‘good’ food is wasted due to an over-conservative shelf life estimation and on the other hand, unacceptable products can remain in the food chain if the stated expiration date is based on inadequate quality modelling and/or unrealistic assumptions about the ability to impose the conditions of the food chain.

However, ‘use-by’ labelling should not be viewed as a guarantee of food safety, as this would imply absolute control and no temperature deviations throughout the food supply chain. The ultimate goal of all parties involved in food supply is to optimally and sustainably balance consumer protection and satisfaction with the reduction of global food waste based on a quantitative knowledge of food quality, factoring in the uncertainties of the food chain.

It is crucial to have efficient tools to systematically measure and describe food quality degradation as a function of intrinsic and extrinsic factors in order to predict food status at any point in its processing or distribution to the end user. This could be accomplished by appropriate mathematical models that can quantify food quality and allow optimisation of food processing and/or storage conditions to maximise quality retention. Such tools would provide the food industry with a scientific means to connect physical product properties, processing and distribution conditions with end-product quality and stability, as well as final consumer acceptance.

Since deteriorative reactions are bound to occur after harvesting, in processing and during storage and distribution, delivering quality food products depends on being able either to modify the instabilities of major constituents or to choose optimal storage conditions that minimise the kinetics of the associated biochemical or physical reactions. Even if microbial action is controlled via appropriate combinatorial treatments, quality is bound to decrease due to biochemical and physical reactions. Accordingly, in order to retard such deterioration and to extend the expected shelf life, it is crucial to understand and quantify, through appropriate kinetic equations, the effect of the main factors, intrinsic and/or extrinsic to the food, that control component degradation.

This article reviews current approaches to food quality modelling and practical implications.
it is possible to apply the first procedure, attempting to interpret the results using also the appropriate theoretical background. In the established and more frequently employed two-step approach to food quality kinetics, the most representative quality indices are selected, and their changes are measured as a function of processing or storage time at constant temperature conditions. Then, an appropriate mathematical model is applied to describe the rate of these changes at each temperature. The second step is to select another equation (secondary model) that best describes the effect of temperature, or any other appropriate kinetic parameter, as predicted by the primary model, on the rate of changes.

Alternatively, the model parameters can be determined in a single step considering all isothermal datasets and performing a non-linear regression through appropriate mathematical equations, which are developed by incorporating the secondary into the primary model. Another approach involves the simultaneous determination of all kinetic parameters through a single experiment at dynamic non-isothermal conditions. Despite giving reliable results and reducing significantly the experimental time, there are some practical disadvantages, such as the need for a more sophisticated optimisation method than the isothermal methodologies, the careful experimental design needed regarding measuring times and, most importantly, the risk of miscalculating the variability of kinetic parameters, if not enough degrees of freedom are used.[10] The developed primary and secondary models should be validated by comparing the calculated quality values with measured ones via additional independent experiments. Validated, mathematical models can be a useful tool to quantitatively predict quality at any stage and set of conditions in the food chain.

Basic principles

The ‘primary model’ describing either the loss of one or more quality indices, symbolised by A (e.g. a nutrient or characteristic flavour) or the formation of an undesirable product B (e.g. an off-flavour or discoloration) is in general expressed by Equation 1.

\[ \frac{d[A]}{dt} = -k\cdot[A] \]  

\[ \frac{d[B]}{dt} = k\cdot'[B] \]  

The rate constants [A] and [B] are quantifiable chemical, physical, microbiological or sensory parameters, identified and selected to representatively describe the quality deterioration of the particular food system. The constants k and k’ are the rate reaction rate constants and n and n’ are the apparent orders of the respective reactions. The use of the term ‘apparent’ indicates that Equation 2 does not necessarily describe the mechanism of the measured phenomenon. The reaction orders and constants are determined by fitting the change with time of the experimentally measured values of A or B to Eq. 1 by Differential or Integral Methods[9]. Integrating Eq. 1 leads to a general expression for quality:

\[ Q(t) = \sum_k \frac{k}{k'} \cdot t^{(n-n')} \]  

where Q(t) can be defined as the quality function of the food and k, the apparent reaction rate constant, is a measure of composition factors C, such as concentration of reactive compounds, inorganic catalysts, enzymes, reaction inhibitors, pH, water activity, etc. Activity, as well as microbial populations, and environmental factors, E, such as temperature, relative humidity, total pressure and partial pressure of different gases, light and mechanical stresses. The analytical form of Q(A) depends on the reaction order, and is shown in Table 1. For example, many food quality related actions are described as 1st order phenomena e.g. microbial death, thermal denaturation of proteins, vitamin loss in frozen, canned and dry food, oxidative colour loss, whereas other actions e.g. related to non-enzymatic browning, texture loss, overall sensory deterioration, as n=0 order.

Table 1 Quality function for different reaction order reactions

<table>
<thead>
<tr>
<th>Reaction Order</th>
<th>Quality Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st order</td>
<td>Q(t) = k\cdot t</td>
</tr>
<tr>
<td>2nd order</td>
<td>Q(t) = k\cdot t^2</td>
</tr>
<tr>
<td>0th order</td>
<td>Q(t) = k</td>
</tr>
</tbody>
</table>

Modeling temperature dependence of reactions in foods

Secondary mathematical models describe the dependence of rates, calculated from experiments in set constant conditions, on external factors, such as temperature, pH, aw etc. The paramount effect of temperature on food related reaction rates has long been at the centre of research since it strongly affects product quality and shelf life.

The first practical approach of a temperature secondary model is the Q10 value, i.e. the ratio of the reaction rate constants (or equivalently the inverse ratio of shelf life, t1/2) when the food is stored at a temperature higher by 10°C. Most food literature represents this point data rather than complete kinetic modelling of quality loss. The Q10 approach in essence introduces a temperature dependence equation of the form (Eq.3):

\[ k(T) = k_0 \cdot 10^{\frac{Ea}{10T}} \ln b = \ln k_0 + b \cdot T \]  

where k0 is the rate constant at the reference temperature T0 (K), R: the universal gas constant and Ea: the activation energy (J/mol or cal/mol). The Arrhenius equation implies that a straight line is obtained when the rate constant values are plotted vs. 1/T. Other secondary models have also been used (such as the Williams-Landel-Ferry, the Eyring-Polanyi equations etc).[3,4,5,6] Most of these equations, including the Arrhenius, although developed based on principles of chemical kinetics and thermodynamics, are empirically applied for complex food systems and do not imply a true mechanism. Hence the value of the Ea is usually an ‘activation energy’, as defined in thermodynamics, but rather a measure of temperature dependence of the studied reaction.

Since the Arrhenius equation is widely employed (often in the same empirical sense) for a variety of phenomena in physics, biology and engineering, the Ea value offers a universal measure of comparison of temperature ‘sensitivity’. Food quality related reactions, chemical, biological and microbiological values of Ea are in the range of 50 to 120 kJ/mol, corresponding roughly to Q10 values of 2 to 5. For microbiological reactions (growth and/or inactivation), more elaborated equations have been proposed (Baldwin, square root, log-logistic, probability model, y-concept, etc)[3,9,10].

Practical implications: prediction of remaining shelf life

The application of the primary and secondary models would allow for both a reliable prediction of the quality loss of the product in question at a range of time-temperature conditions that differ from the experimental ones[10] and as a basic tool to implement a thorough shelf life study, based on the principles of Accelerated Shelf Life Testing (ASLT) methodology.

Continuous monitoring and verification of the shelf life of food products is necessary and requires the development of practical systems that can monitor, record and translate the temperature effect of food quality from production to consumption.

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4 Evaluation of the duration, type and frequency of testing, based on available information on the most likely $Q_0$. If no information is available on the expected $Q_0$, a minimum of three testing temperatures should be used. At each storage condition, at least six data points are required to minimise statistical errors, otherwise, the additional $Q_0$-Prevalence at the obtained shelf life value is significantly reduced.

5 Plot of the data as it is collected to determine the reaction order and to decide whether test frequency should be altered.

6 For each test condition, determination of the reaction order and prediction of the shelf life at the desired storage condition. In order to validate the model obtained, it is an effective practice to test the obtained predictive shelf life model by conducting an additional test at a controlled variable temperature.

For this purpose, the value of the quality function at time $t$, already defined by equation (2) in the case of isothermal conditions, is calculated by the following integral, where $T(t)$ describes the change of temperature as a function of time:

$$Q_{(A)}(t) = \int_{t_0}^{t} \frac{k_{\text{eff}}}{T(t)} \, dt = k_{\text{eff}} \int_{t_0}^{t} \frac{1}{T(t)} \, dt,$$

where $k_{\text{eff}}$ is the value of the rate of the quality loss reaction at the effective temperature. $T_{(t)}$ is defined as the constant temperature that results in the same quality value as the variable temperature distribution over the same time period. If the $T(t)$ function can be described by a step sequence, or, equivalently, can be discretised in small time increments $\Delta t$, of constant temperature $T_i$ (with $\sum \Delta t = \tau_{\text{tot}}$), then Equation 5 can be expressed as Equation 6, applying the assumption of the Arrhenius equation:

$$k_{\text{eff}} \approx \sum \exp \left( - \frac{E_a}{R} \left( \frac{1}{T_i} - \frac{1}{T_{\text{ref}}} \right) \right),$$

where $E_a$ is the activation energy of the chemical reactions and $R$ is the universal gas constant. Based on available results, a shelf life experiment can be adequately designed (length and frequency of measurements), taking into account the range of $E_a$ and the principles of ASLT methodology.

In Figure 2, indicative results and diagrams for Vitamin C loss $C_{(t)}$ at each stage of the respective Arrhenius plot are presented.\[12\] Kinetic data used for this case study for the two quality indices are summarised in Table 3.

Based on these estimates, spinach total shelf life $T_{(t)}$ can be predicted at any constant temperature, based on a predetermined acceptability and criterion, e.g. 70% Vitamin C loss and 60% chlorophyll retention. For example, for Vitamin C loss, shelf life $T_{(t)}$ can be estimated, using the following equation and the results are given in Table 3.

$$T_{(t)} = \frac{1}{k_{\text{eff}}} \ln \left( \frac{C_{(t_0)}}{C_{(t)}} \right).$$

Therefore, shelf life of the food product can be estimated at designated temperatures based on either quality criterion.

To study the shelf life of frozen spinach leaves, a literature review can assist in selecting the most representative quality indices. A systematic kinetic study was conducted at constant temperature, using as main indices Vitamin C and chlorophyll loss.\[13, 14\] A first-order reaction was found to describe the above chemical reactions, namely:

$$C_{(t)} = C_{(t_0)} \cdot \exp \left( -k_{\text{eff}} \cdot \frac{t}{T_{(t)}} \right),$$

and the Arrhenius equation was applied to describe temperature effect.

$$k_{\text{eff}} = k_{\text{ref}} \cdot \exp \left( - \frac{E_a}{R} \left( \frac{1}{T_{(t)}} - \frac{1}{T_{\text{ref}}} \right) \right),$$

where $C_{(t)}$ is the initial value, $C_{(t_0)}$ is the activity energy of the chemical reactions and $R$ is the universal gas constant.

As shown in Table 2, the shelf life of frozen spinach leaves, based on the index that defines the end of shelf life (Table 3) is Vitamin C loss; in this context, using the 70% Vitamin C loss for end-criterion, the first order reaction and the Arrhenius results, values of $k_{\text{ref}}$ and the remaining concentration of Vitamin C (and thus the $S(t)$) can be calculated after each stage (Figure 3).

Assuming the following hypothesis distribution scenario (two initial isothermal steps, e.g. distribution to warehouse and retail display), it is possible to predict the remaining shelf life of the product, when stored in a domestic freezer of average temperature -12°C. At this temperature, the index that defines the end of shelf life (Table 3) is Vitamin C loss; in this context, using the 70% Vitamin C loss for end-criterion, the first order reaction and the Arrhenius results, values of $k_{\text{ref}}$ and the remaining concentration of Vitamin C (and thus the $S(t)$) can be calculated after each stage (Figure 3).

In Figure 3, shelf life has reached its end after 158 days of rotation, taking into account the equivalent isothermal steps of the assumed T7 profile.

However, temperature in each stock-rotation step is not actually a single value, but it is better described by a distribution of values. Therefore, taking into account the actual distribution of the effective temperatures at each stage, $SL_{(t)}$ at the end of the 1564-cycle, is expressed by a distribution, showing also the uncertainty of the mean estimate, information that should not be overlooked.

In our case, by introducing the actual temperature distributions of Stage 1, 2 and domestic storage (Figure 4), the $SL_{(t)}$, after almost 160 days in the frozen chain show that almost 20% of products are beyond their limit of acceptability (based on the nutritional limit of 70% Vitamin C loss).

The above equations with the appropriate parameters can be easily integrated in user friendly software, often referred to as ‘tertiary models’, that can serve as practical tools for examining alternative scenarios in the food chain leading to improved monitoring and optimisation and a more realistic, scientifically supported shelf life declaration.

There are no uniform, established theories for predicting food reaction kinetics.

References and article available online at fspjournal.org/Features/33-1/Food-quality

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Conclusions and further considerations

There are no uniform, established theories for predicting food reaction kinetics models, and parameters based on experimental observations are empirical in nature and derive from a specific food matrix and the processing/storage conditions. Additionally, caution is necessary when making assumptions about the application of particular primary or secondary model.

Another important observation is that there has been little attention in the food science literature to the statistical quality of parameters, and especially their uncertainty. Therefore, in addition to the well-known biological variability of foods, it is important to study the significance of the uncertainty of parameters in more detail, certainly if the scope is to make real model predictions.\[15\] In order to alleviate this weakness, the use of techniques, such as Monte Carlo simulation, seem very promising.

A final issue relates to the dynamic conditions occurring in the distribution chain of perishable foods. Application of an optimised quality and safety assurance system for the chilled and frozen distribution chain requires continuous monitoring and control of storage conditions, from production to consumption, using smart or intelligent packaging to monitor shelf life in the non-isothermal conditions of the food chain.

Time-Temperature Integrators (TTI) are smart labels that show an easily measurable temperature-dependent change that cumulatively reflects the thermal history of the food product. Based on reliable models of shelf life and the kinetics of the product and the TTI response, the effect of temperature can be monitored and quantitatively translated into food quality, from production to consumption.

The selection and use of the optimum TTI for a particular product could lead to realistic control of the cold chain, while reliable monitoring of the shelf life and the remaining shelf life could be performed, allowing for better management and optimisation along the food chain.\[16\]

Figure 4 presents a three-isothermal step time-temperature distribution of frozen spinach leaves, showing also the uncertainty of the mean estimate, information that should not be overlooked. In our case, by introducing the actual temperature distributions of Stage 1, 2 and domestic storage (Figure 4), the $SL_{(t)}$ after almost 160 days in the frozen chain show that almost 20% of products are beyond their limit of acceptability (based on the nutritional limit of 70% Vitamin C loss).
All change for food regulation

Michael Jackson, Head of Regulatory Standards and Assurance for the FSA’s Regulating Our Future Programme, explains the thinking behind the new programme and how it will operate.

Introduction
Four months before the referendum on membership of the European Union (EU), the Food Standards Agency (FSA) launched Regulating Our Future (ROF), a programme of work aimed at modernising the way food businesses in England, Wales and Northern Ireland are regulated. At the time, the two were not linked but since the UK’s decision to leave the EU, the ROF programme’s objectives have taken on added significance.

To clarify, ROF is not about changing the food safety regulations that have been in place for many years in the UK. When the UK leaves the EU, those regulations will remain in place. Instead, ROF is redesigning the system through which these rules are enforced. That system, largely based on inspections carried out by local authority staff and overseen by the FSA, has remained unchanged for many years. It has not kept pace with changes in the food industry or advances in technology nor does it reflect the current landscape of local authority funding.

A new approach is needed.

Since February 2016, the FSA has been working closely with the food industry, local authorities and consumers to identify what that new approach should be. These discussions have been challenging but fruitful. We have established the need for the new model of regulation to be financially sustainable and resilient. It must be capable of adapting to future needs as well as changing patterns of food production and consumption.

It needs to be ready for our new relationship with the EU, allowing us to continue to trade confidently with our European neighbours, and also with trading partners around the world. That confidence must also be maintained at home. We need to make sure that the public in the UK retain the trust in the food system that the industry, local authorities and the FSA have worked hard over the years to build up.

Data and new technology have emerged as key to delivering a modern, new system of regulation. Many food businesses and assurance schemes are already generating large amounts of quality data that could be potentially harnessed to ascertain whether those businesses are doing the right thing for consumers. We are exploring the feasibility of how this data could be used and which technologies provide solutions for capturing and making it available to regulators.

Not all of these changes can be achieved immediately, but we have set 2020 as the target for having the new model of regulation in place. This is a challenging target but the ROF programme is one of the FSA’s key priorities and we are committed to transforming the model.

I would like to take this opportunity to explain in more detail the vision set out by the ROF programme and how we are delivering it.

Why do we need to change?
It may come as a surprise to many people that under the current system used to regulate food businesses, the FSA, which is the central competent authority for food safety, does not have an overview of all registered businesses.

That information is held by individual local authorities and it is not always updated regularly by food business operators, so we do not have an accurate picture of all food businesses in England, Wales and Northern Ireland. Under the plans we have developed through ROF we intend to change that.

The current delivery model is outdated. The approach that was used to regulate food businesses before the internet is trying to keep pace with a food chain that is increasingly moving online. New technology, changing patterns of consumption, and an ever-more complex food chain provide challenges and opportunities to create a more modern, risk-based, proportionate, robust and resilient system.

Our current model is also financially unsustainable. Wider Government policy is moving regulators away from a system where the taxpayer picks up the costs of regulation. Local authorities are already finding it increasingly challenging to fund the current system, so we need to look at more sustainable ways of keeping consumers safe.

Finally, EU Exit looms large over all of the FSA’s work and none more so than for the ROF programme. The new system we put in place must, in a post-EU Exit world, inspire confidence in those who will be deciding whether our system of regulation is robust enough to maintain our trading position in the world.

The ROF programme
We started with five key principles to underpin our programme of transformation:

• Businesses are responsible for ensuring that food that is safe and what it says it is, and should be able to demonstrate that they do so. Consumers have a right to information to help them make informed choices about the food they buy – businesses have a responsibility to be transparent and honest in their provision of that information.

• FSA and regulatory partners’ decisions should be tailored, robust and resilient.

• The regulator should take into account all available sources of information.

• Businesses doing the right thing for consumers should be recognised; action will be taken against those that do not.

• Businesses should meet the costs of regulation, which should not be more than they need to be.

We have used these principles to develop the blueprint for a new model of regulation. This target operating model describes the regulatory journey we envisage businesses of all sizes taking.

The blueprint
For all new food businesses, the journey will always start by registering with their local authority. Throughout the consultation process we have been emphasising the continued importance of local authorities in the new system. We have been sensitive to their concerns about the role of local enforcement officers and how their jobs may change. However, we are adamant that their expertise is still going to play a vital role, but within a transformed model.

The first part of the model involves developing an Enhanced Registration system. The current approach to registration of food businesses is not fit for purpose and many new businesses do not proactively register. This means that local authorities often just do not know enough about the food businesses they have to regulate: who owns them, exactly what they are doing and what risks they present. Under the new system we want to learn more about food businesses before they start to operate and to make it easier for them to access the guidance and support to help them comply with food law. Work is underway to develop a digital solution that will provide a unified view of all food businesses and enable us to see as a priority for EU Exit. We are aiming to have the new solution in place by April 2019.

Once registered, businesses will be segmented. Segmentation recognises that not all businesses present the same risks to the public. Each business will therefore be assessed to decide if, how and when it needs to be
Our message to businesses is: take your obligations to comply with food law and produce safe food seriously or be prepared to face the consequences.

In this approach, local authorities would continue to undertake reactive work, verification checks and enforcement where required. In this approach, local authorities would continue to undertake reactive work, verification checks and enforcement where required.

The introduction of National Inspection Strategies would release local authority resource that could then be targeted at those businesses presenting the greatest risk. It would also make more effective use of the assurance data already captured by the businesses.

This is looking at compliance of multi-site businesses through Primary Authority partnerships to inform the development of National Inspection Strategies. The introduction of National Inspection Strategies would release local authority resource that could then be targeted at those businesses presenting the greatest risk. It would also make more effective use of the assurance data already captured by the businesses.

The FSA is playing a leading role in taking it forward at EU level and in Codex. An example of development in this area is the pathfinder trial we are undertaking in England. This is looking at compliance of multi-site businesses through Primary Authority partnerships to inform the development of National Inspection Strategies. The introduction of National Inspection Strategies would release local authority resource that could then be targeted at those businesses presenting the greatest risk. It would also make more effective use of the assurance data already captured by the businesses.

The new approach here is one that is gathering the nature, frequency and we will set. This will inform data that meets the standards local authorities. We intend to implemented by the FSA and in the official control regime.

In the current model there is limited use of the data gathered by industry, either directly or through second or third parties, in the official control regime implemented by the FSA and local authorities. We intend to change that and to use industry data that meets the standards we will set. This will inform the nature, frequency and intensity of official controls. This approach is one that is gathering momentum more widely and the

Article available online at fstjournal.org/features/32-1/regulating-our-future

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If you would like to keep up to date on how the ROF programme is progressing, then please visit our webpage at: food.gov.uk/enforcement/regulation/regulating-our-future

The risk of food recalls

No news story captures the headlines or the nation’s attention quite like a public food recall. But looking beyond the headlines and hysteria, product recalls can be the most critical risk facing a food and beverage (F&B) business.

Taking a product off the shelf due to contamination or mislabelling dents consumer confidence in the brand and the retailer. It can also have a knock-on effect on other similar products. The impact of recalls is wide-ranging, costing a business on average $10 million[1].

Worryingly, recalls are rising. Lockton’s recent analysis of Food Standards Agency (FSA) data highlights a 70% increase in product recall alerts since 2012[2] while half (50%) of UK food and beverage manufacturers have witnessed an increase in the number of product recalls in the past five years[2].

The industry is changing rapidly; while those changes present new opportunities for businesses, they also present new challenges. New technologies, new suppliers and new products can all boost the bottom line, but they can also introduce new risks.

Man vs machine

Increased automation in the food production process could go one of two ways in terms of product recalls. Reduced human involvement in the food production process, by definition mitigates the risk of human error. Employees can often be responsible for cross-contamination of products on the production line, mislabelling or product contamination as a result of personal illness or lack of personal hygiene. Recent research highlighted the risk of human interference presents to the production line, with Esko estimating that 60% of product recalls are the result of human mistakes[3].

In a recent report on the
pressures facing UK food and beverage manufacturers, Lockton found that 95% of manufacturers have either already introduced or are considering additional automation in the manufacturing process to meet pricing pressures\(^\text{9}\). Cost of labour is a significant expense in the manufacturing process, and one that is only set to rise in the wake of Brexit. Increased automation in the production process is therefore becoming an increasingly attractive option to manufacturers as they try to protect their squeezed margins.

Yet while automation and technology can reduce the frequency of recalls, should one occur, technology advances can also significantly increase the severity. With one of the major advantages of increased automation being the ability to produce larger batches of food in a relatively short period of time, should there be an error in the production process this means more products are affected and there is a larger recall to handle.

**Prepared food**

Prepared food is an area of huge growth for the industry, valued at £3.7bn in 2016 alone\(^\text{10}\). Unsurprisingly, many manufacturers and retailers are keen to get a slice of this pre-prepared pie. Yet, while the industry is lucrative and presents considerable opportunity for growth, it also carries a considerable amount of risk.

Our recent Recall Risk Tracker identified that prepared dishes and snacks were amongst the most recalled foods in the past five years, accounting for more than one in 10 (11%) product recall alerts issued by the FSA from 2012 to 2017. Their usage of more ingredients than other food products, from multiple providers and origins, means a larger and more complex supply chain. This creates more opportunities for errors to occur and food safety to be compromised. The risk is not only present in the supply chain, but in the production process too. Once the raw materials reach the production plant, they are subject to many more processes than a bottle of milk or loaf of bread. Production processes for prepared dishes are far more complex, creating more opportunities for error or contamination.

The global food chain

The way we consume food is not the only thing that is changing; the food itself and its provenance has changed considerably in recent years. Turn the clock back sixty years and you would probably be met with fridge shelves and kitchen cupboards filled with predominantly domestically-grown food.

Since then, our food chain has become increasingly globalised and complex. Travel and globalisation has transformed tastes and diets, while food that was once domestically produced is now more available online at locktoninternational.com.

The science that powers food testing is constantly improving, becoming more stringent and less forgiving.
Safety

We Can Do Better - Approaches

Research is described in the book as well as a synopsis of our past assessing hazards and risks and, concerned having a positive industries that result in all manufacturing and catering organisations and individuals managed properly and effectively, to date lead to the conclusion. The authors’ research findings undesired extent incidents still happen to an outbreaks, food scandals and quality and integrity, food-borne .

Background
Food chains have changed dramatically because of technical and demographic changes over the last decades. Although efforts are made to ensure high quality and integrity, food-borne incidents still happen to an undesired extent[1]. Since 2016 there have been further incidents, including in October 2017, when Food Manufacturer Magazine published a report entitled ‘UK’s top supplier of supermarket chicken ‘fiddles food safety data’. An investigation by The Guardian and ITV News recorded undercover footage of workers altering the slaughter date of poultry being processed at a 2 Sisters Food Group plant. The group produces one third of poultry products eaten in the UK and supplies top grocers including Tesco, Sainsbury’s, Marks & Spencer, Aldi and Lidl. Ranjit Boparan, the boss of 2 Sisters Food Group appeared before a House of Commons Environment Food and Rural Affairs (EFRA) select committee, where he agreed to fund Food Standards Agency (FSA) inspectors across all 2 Sisters plants as well as implementing CCTV in all areas and improving staff training to restore confidence in its poultry production[2]. Boparan declined to answer a direct question on whether there was a breach in food safety regulations but admitted there had been ‘mistakes’. The chairman of the EFRA select committee, Neil Parish MP, accused the UK’s main meat assurance schemes of being ‘culpable’ for the alleged breaches of food safety identified in this undercover press investigation at the 2 Sisters Food Group factory in West Bromwich[3]. The fact that 2 Sisters was supplying so many major retailers implied that their factories must be audited and inspected very frequently. Marks and Spencer and Tesco have their own high food safety and quality standards, as has the British Retail Consortium (BRC). Many other food incidents that have resulted in serious illness and sometimes even death have come to the public attention over the last two decades. For example, BSE and the E. coli outbreak in South Wales[4] suggest that food safety controls, including auditing and inspection, need to be continually reviewed and improved[5].

Regulating Our Future
The FSA has recognised the need for improvement in the way it delivers regulatory assurance and has launched a project called ‘Regulating Our Future’ (ROF) to address this.

With a target date for implementation of 2020, the intention is not to change existing regulations but, as described in the document entitled ‘Regulating Our Future’ – Why food regulations need to change and how we intend to do it, to improve delivery of controls across the food chain, including those for animal feed, by prioritising improvement where there has been no modernisation of the system in recent years and where FSA perceives it is most needed.

The FSA believes that the existing ‘one size fits all’ approach is ill suited to the current diverse nature of the food industry, which has seen large numbers of new players enter the global food and food safety landscape, for example, online retailers, food delivery services and private auditors. It also points out that many of these developments have created different risks resulting in increased risks in many areas.

Importantly, ROF seeks to reduce the regulatory burden on business. It suggests that appropriately trained and competent auditors will be able to inspect/audit businesses and pass the results of their audits to local authorities, which would then use the information to calculate an inspection risk rating – the frequency of inspection – but also the food hygiene rating.

Simon Neighbour, Environmental Health Manager of Preston City Council and co-author of this article, believes that some environmental health professionals employed in local government have concerns about this approach. Recent years have seen an increasing number of Environmental Health Practitioners (EHPs) employed in the private sector and as the voice of the profession is no longer the preserve of local authority EHPs, but rather a wider spread of views. The authors suspect there will be some differences in the views of professionals in the different sectors. Broadly, local authority EHPs would prefer independent regulation and see this as yet another route to self-regulation. The views expressed so far by EHPs were broadly reflected by Professor Liza Ackerley at a 2017 CIHE safe food conference[6]. Proposing a radically simplified single food safety assurance national scheme for all, she says: ‘Businesses don’t want someone going in and waving a great big stick and then someone else going in and doing a ‘good cop bad cop’ thing, so the visit they get, whether it’s from a local authority or a private sector auditor, needs to help them to get to the place where they need to be.’ For the food manufacturing industry this idea is not new. Her proposed not-for-profit scheme, covering the catering sector only, would involve a centrally-held database. Local authorities would be able to view relevant parts of the database, but, because it was not held in the public domain, it would not be subject to freedom of information requests. Businesses do not want all of this data, which has been clearly been private, being requested by the Daily Mail.’ The central body building the database would work with stakeholders to set standards and competencies for auditors, including training requirements. But she stressed: ‘We don’t want to put too many barriers up or to make this too expensive.’ It would not be compulsory for auditors to join the scheme. She reassured her audience – this is absolutely not about stealing EHO jobs.’ Under the new system, local authorities would still be responsible for enforcement activity, including awarding food hygiene ratings and re-ratings. But, in some cases, it would be informed by data from external auditors. ‘Local authorities would be doing
Regulating and managing food safety using audits and inspections is key in both private or public food industry bodies.

The new paid-for service would be based on the British Hospitality Association’s Catering Guide, with reference to Annex 5, Food Standard’s Agency’s food law code of practice. The paper argued that it would simply regularise existing accreditation schemes, like the British Retail Corporation (BRC), major retailers and those that already have some specific requirements or expectations in standards of food, differ in that they are not set to food hygiene and food safety legal standards. They are based on their own requirements for best practice, quality and specific interests[8]. For example, the Soil Association is concerned with organic food and the Red Tractor to ensure food is traceable, safe to eat and has been produced responsibly. It covers animal welfare, food safety, traceability and environmental protection. It is restricted to food that has been farmed, processed and packed in the UK.

In the paper ‘Approaches to and the management of the audit process in the food industry’, one of the key findings was that the frequency, number and number of audits and inspections in the food manufacturing sector, unlike inspections carried out by local government, are not risk based. The annual auditing of food premises is the common subjective norm rather than being risk related. This appears to be contrary to the principle and legal requirements that the food safety management of food premises must be risk-based as per Article 6 of 178/2002, and that food businesses shall produce food in accordance with the risk-based approach described in Article 5 of Regulation (EC) No 852/2004.

In the authors’ view, as part of the management’s control of food hygiene across the food chain, appropriate interventions, which ensure a consistent level of compliance with food law and maintenance of hygiene standards to ensure food is safe for human consumption, must be achieved without entailing excessive cost, while satisfying consumer concerns over integrity.

Auditing frequency

The number and frequency of audits is also driven by other factors:

1. The number of customers a business has, who they supply and whether they are required to meet certain specialist areas of supply and claims made about their products: e.g. gluten free, organic or fair trade. They agreed to be based on custom and practice: i.e. the annual auditing of food premises is the common subjective norm rather than being risk related. This appears to be contrary to the principle and legal requirements that the food safety management of food premises must be risk-based as per Article 6 of 178/2002, and that food businesses shall produce food in accordance with the risk-based approach described in Article 5 of Regulation (EC) No 852/2004.

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Further duplication of effort and cost can also be averted if an audit or inspection has been carried out recently by a recognised body. This approach is dependent on trust and would entail different auditing bodies recognising each other’s integrity and an exchange of information between them. This would include providing and sharing audit reports between auditing bodies, suppliers and buyers, thereby enabling all parties concerned to be aware of the strengths and weaknesses, special circumstances or interests in the area covered by the audit. From this information a judgment can be made as to when the next audit should occur.

As described in the FSA’s Food Law Code of Practice (FSA 2017) the system used for determining the frequency of local authority inspections is by identifying a number of risk criteria and allocating a number of points against each one according to the perceived level of risk presented. The higher the points the higher the risk and the more frequent inspections.

The criteria summarised from the Food Law Code of Practice are:

1. Type of food and method of handling
2. Method of processing
3. Consumers at risk
4. Level of (current) compliance
5. Confidence in management/ control procedures
6. Where the production of or the service of high risk foods take place to the vulnerable e.g. hospitals, care homes and children’s nurseries.

The above approach is focused on the easily identified ‘what is happening’ and ‘how is it happening’ approach, with very little opportunity to understand ‘why’. The HSE (Health & Safety Executive) has published a topic note on safety culture. Understanding culture is likely to be an involved and time-consuming task, but offers insight into why employees behave the way they do. Over a period, it should be possible to actively seek to understand the culture of an organisation and thus make appropriate interventions through engagement to protect public health.

References and article

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Blockchain technology has the potential to transform the food industry and herald a food safety and anti-fraud revolution. Sterling Crew examines its application to enhance food supply chain transparency, tracking and traceability and considers how it could play a part in the fight to build consumer confidence in a more secure food system.

The challenge
Food scandals, scares and incidents, such as the recent case of eggs contaminated with the toxic insecticide fipronil, highlight the importance of a robust secure food supply chain. Food safety is key and consumers and watchdogs want to know where their food comes from and to have confidence in its provenance. There is also a strict legal obligation to inform competent authorities immediately if food that may be injurious to human health has been placed on the market and for that food to be effectively withdrawn or recalled.

Effective food security, tracking, traceability and recall management enables food businesses and authorities to build capacity to safeguard food and enhance consumer confidence. As with the affected eggs, current methods can take weeks to track the source of a product.

Traditional systems are often paper-based or use basic tools and have to be reconciled by the various businesses at different points in time, making it difficult to manage safety issues within the supply chain and causing costly delays. The current approach can also often make it difficult to pin point exactly where things went wrong, contributing to the erosion of consumer trust in the food system.

As food supply networks are becoming increasingly complex and globalised, traceability is ever more challenging. The network is so convoluted that it has become almost impossible for food producers and retailers to unconditionally guarantee the provenance of their products. This was demonstrated in 2013 with the infamous horsemeat food fraud scandal, when for an undetermined period of time, food retailers in the UK and continental Europe sold an unknown amount of horsemeat labelled as beef to unsuspecting consumers. Food fraud costs the global food industry some £28 billion a year according to PwC and costs the UK £1.7 billion annually in addition to the damage to organisational reputation and brand loyalty.

More important is the issue of food safety. The UK’s Food Standards Agency states that 500,000 food poisoning cases are reported annually in the UK with close to 500 of these resulting in deaths.

The World Health Organisation reports on the substantial global burden of contaminated food with 800 million people, almost one in ten, falling ill and 420,000 deaths a year. A Blockchain food supply chain management system could be part of the solution and could contribute to its reduction.

What is Blockchain?
Blockchain is a collaborative solution that has the potential to revolutionise traceability and transparency of food across the supply network from farm to fork.

It is widely used in the financial sector as a tool to track and trade stocks, bonds and other assets and is most frequently associated with the cryptocurrency Bitcoin, where it is used to publicly record every Bitcoin transaction. Blockchain, created in 2008, is a shared, immutable ledger for recording the history of transactions. It is called blockchain because all the transactions are sorted into continuously growing lists of blocks and each block is chained, using sophisticated mathematical algorithms, to the ones before it all the way back to the very first transaction.

By design, a Blockchain is inherently resistant to modification of the data. This structure makes it tough for anyone to change the records and provides a quick mechanism for various parties to check and agree on a set of recorded facts, providing greater trust in transactions. Information about what is in the food and its origin could be identified in seconds. Blockchain could provide a new generation of transactional applications that could foster trust, accountability and transparency across the food supply network, making food safety simple by digitalising existing food safety procedures and product information and creating a single secure historical record. This could potentially lower the cost of compliance and increase efficiency. The Blockchain technology is an enabler and not a final solution in itself. It will only work as part of an integrated solution that is supported by a strong company food safety integrity culture.

Blockchain is designed to facilitate secure online transactions. It could help prevent food fraud and counterfeiting issues as each link would be documented in a permanent record that cannot be altered, with instant end to end visibility. Any changes to the blocks require a digital signature, and interested parties would immediately be informed of any modifications. This would help with verification of identification to prevent fraud and building assurance through recording legitimate transactions.

Food fraud
Food fraud occurs when food is deliberately placed on the market for financial gain with the intention of deceiving consumers or customers. This includes the sale of food that is unfit for consumption and potentially harmful or is deliberately misrepresented. Blockchain is not the silver bullet to eliminating all food fraud in the food network, but it could help provide extra security and strengthen safeguards related to food authenticity. Fraudsters are adaptable to the circumstances and constantly change their ‘modus operandi’ to keep up with new security measures. If they have integrated themselves into the legitimate supply chain they could overcome Blockchain systems by entering false information into the blocks. It may still be necessary to audit the points of data entry at farms, distribution points and processing plants to observe how the data is being recorded and entered and to validate it. The goods also need to be physically secure to maintain integrity so that criminals cannot replace legitimate goods with counterfeit or adulterated products.

Blockchain by its very nature has a decentralised structure. This has a great advantage in the fight against fraud, as centralised data is more susceptible to record manipulation. By storing data across its network, the Blockchain eliminates the risks that come with it being held centrally and makes data transparent to everyone involved.

Future challenges and developments
It is inevitable that the early adopters of Blockchain technology in the food chain will be larger corporations with global interests and significant resources. The value of their brands’ reputation will be higher...
and they will have more to lose. Most of the supply chain consists of small and medium-sized enterprises and many of these lack dedicated sophisticated platforms for the exchange of logistical transactions. Initiatives are now needed to determine optimal approaches and tools for blockchain technology to be effective in supporting a global, highly complex food supply network. It must be accessible to all food chain operators, irrespective of size or geographical location, from small individual farmers in developing countries, through brokers and shippers, up to large multinational manufacturers and retailers and ultimately the consumer.

A Blockchain system inclusive of smaller, local vendors will probably take longer to develop. What is clear is that the benefits of Blockchain will not be truly enjoyed until it covers the entire food network and that a common system is adopted internationally.

Individual private bespoke in-house Blockchain solutions could be nothing more than a Band-Aid on a wound. The food supply Blockchain system must align and be fully integrated.

A consensus is building that Blockchain is the next food safety and anti-fraud revolution, a genuine paradigm shift in the way that the industry operates.

There may be some barriers to this as some members of the chain may be distrustful and may be wary about sharing their information and intellectual property unless they have confidence in the security, confidentiality and robustness of the transaction.

Recent high profile hacking incidents have played a part in undermining organisational confidence. Understandably, to mitigate risk, businesses may be reluctant to place Blockchain at the core of their business structure.

A Global Food Blockchain Initiative has recently been formed to bring the food chain together in a not-for-profit collaboration consortium to facilitate the building of an effective universal blockchain for food as a trusted source of information. The food supply Blockchain system must align and be fully integrated.

A key barrier is that Blockchain is the next food safety and anti-fraud revolution, a genuine paradigm shift in the way that the industry operates.

When it comes to the food supply chain, the technology will fundamentally change the way we transact food and do business, opening up new opportunities to enhance food security.

What the internet did for communications and information, Blockchain will do for trusted transactions.

The key to making this work is that everyone at every link along the food chain needs to be involved.

Early adopters, such as IBM and Walmart working with Tsinghua University in China, are already testing Blockchain to strengthen their food supply chain and to create new levels of trust. GS1, the global business communications standards organisation, announced a collaboration with IBM and Microsoft to leverage GS1 Standards in Blockchain application.

Blockchain could provide consumers, suppliers, manufacturers, retailers and regulators greater transparency and confidence in our food. It will connect the food to digital products, such as a food traceability, batch, numbers, manufacturer’s and processing data, site certification, expiration dates, weather conditions, logistical details and claims substantiation.

This data can be captured along with details of allergen cross-contam exposure and additives, veterinary drugs, such as antibiotics or hormones, and application of biocides and agrochemicals, such as herbicides and pesticides.

As tools, such as handheld devices for DNA/gene sequencing and chemical identification using transmission raman spectroscopy (TRS) sequencing, coupled with blockchain information technology provide faster and wider-reaching data, the lag time between observing an outbreak of food-borne disease or contamination and pinpointing its cause will fall dramatically.

The use of the latest low-cost RFID technology could even enable the tracking of individual cans and packs. Blockchain has the added promise of bringing significant efficiencies and the reduction of food waste to the global food supply chain.

It could also assist with the increasing requirement to supply sustainability information. In a post Brexit world there is a potential to help with smoother and speedier import and export transactions.

It would also allow stakeholders to more clearly identify those who do the right thing and so could not only result in increased food safety but also reward competent, honest food chain operators with increased profitability and business growth.

Consumer choice

As well as improving food safety and reducing potential for fraud, Blockchain has the potential to shape the future of the Chilled Food Association to take this work forward.

Our work to influence education policy makers and governments in England is a key policy priority, we continue to call on the UK Government to recognise that food is an excellent vehicle to teach children science, supporting priorities in public health, an innovative economy and the need to move towards a more sustainable food system. We accept that it takes time to shift policy priorities and develop curricula but concerted effort alongside our partners will see a dividend in the medium term.

In the shorter term, IFST is well placed to have an immediate positive impact on the education and career choices of the students of today.

Pilot study

In spring 2016, we ran a small pilot of a mentoring scheme with the aim of bringing schools and food scientists together to support the delivery of the new GCSE.

The feedback from teachers, students and mentors involved was overwhelmingly positive. We used the pilot to develop a business case and by mid-December 2016, the IFST Board approved a project to redevelop the ‘Love Food, Love Science’ website to focus on meeting the needs of secondary school food and science teachers, bringing together the various strands from the Education Forum.

Food investigation

We worked with the Food Teachers Centre in early 2017 to look at the resources available to food technology teachers. We discovered plenty of food-related resources but that teachers were hard-pressed to identify what was relevant and credible, they just wanted quick access to resources they could trust.

We also found that the ‘food investigation’ non-examined element of the new GCSE (15 marks) was a source of anxiety among some food teachers. Our research also showed that basic food science concepts, particularly for new or less able students, were absent or fairly limited in many existing resources.

Addressing these issues, Love Food, Love Science aims to focus on the food investigation element of the new GCSE, signing up credible video and text resources for use in the classroom and enable teachers to access food science mentors (IFST members).

The food investigation is a key opportunity for IFST to improve student outcomes and the success of the course generally. With the kind help of PhD student, Holly Cuthill, we filmed five videos in March 2017 to help students understand:

- how to plan, research and carry out some basic investigation
- how to conduct experiments and make a fair test
Being a member of IFST provides you with a whole range of benefits to support your professional development. But, more than this, you’re part of a professional network which is working tirelessly to:

**SETTING AND RECOGNISING PROFESSIONAL STANDARDS**

The food and drink sector demands high levels of expertise and professionalism to ensure that our food is always of the highest possible standard. Our professional registers are widely recognised and valued throughout the sector as the benchmark for skills and expertise for food professionals.

**DELIVERING AN INDEPENDENT VOICE**

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