FOOD SAFETY CULTURE

STRENGTHENING SAFETY CULTURE

FOOD SAFETY TRAINING
FOOD SAFETY BEHAVIOUR
CERTIFICATION OF FOOD SAFETY CULTURE
NEW PRODUCT DEVELOPMENT
NUDGE BEHAVIOUR
NATURAL CAPITAL
PALM OIL CERTIFICATION
PLANT FACTORIES OF THE FUTURE
PESTICIDES IN AGRICULTURE
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Planetary health diet

The EAT-Lancet Commission on Food, Planet, Health, was launched in Oslo in January 2019 and has subsequently been introduced in a series of events around the world. The EAT’s non-profit startup dedicated to transforming the global food system through sound science, important disruption and novel partnerships gathered 37 of the world’s foremost experts, led by Prof. Johan Rockström (Potsdam Institute for Climate Impact Research and Stockholm Resilience Center) and Prof. Walter Willett (Harvard University), who, for the first time ever, have proposed scientific targets for both a healthy diet and a sustainable food system.

A new study by plant scientists at the University of Dundee and the James Hutton Institute, led by Dr Sarah McKim, suggests that new barley lines having a shorter stature could benefit the brewing and distilling industries. The next step

New tool provides dietary information

EFSA has launched an European Union regulatory framework for the assessment of dietary fibres (DBFs). The DRIFinder searches by population group or nutrient, allowing users to extract and combine the precise information they need from the 32 opinions on DBFs that EFSA has published in recent years. The opinions contain DBFs for water, fats, carbohydrates and dietary fibre, protein, energy, as well as 14 vitamins and 13 minerals. Health professionals and authorities, risk managers, policy-makers, food manufacturers and scientists are expected to use the DRIFinder to help consumers make healthy food choices.

Blueprint for resources and waste

Businesses and manufacturers will pay the full cost of recycling or disposing of their packaging waste, under a new government strategy unveiled by the Environment Secretary, Michael Gove, in December 2018. The move will overhaul England’s waste system, putting a legal onus on those responsible for packaging as a way to reduce packaging waste to foot the bill for its recycling or disposal.

The announcement forms part of the Government’s new Resources and Waste Strategy, the first comprehensive update in more than a decade. It aims to eliminate avoidable plastic waste and reduce environmental contamination. It will be funded by industry through an Extended Producer Responsibility (EPR), which will see industry pay higher fees if their products are harder to reuse, repair or recycle and hopes to encourage sustainable design, subject to consultation.

The Resources and Waste Strategy addresses a number of issues that are of specific relevance to the food sector. It aims to:

- allow producers pay the full net costs of disposal or recycling of packaging they place on the market by extending producer responsibility
- introduce a consistent set of recyclable materials collected from all households and businesses, and
- consistent labelling on packaging so consumers know what they can recycle, to drive-up recycling rates ensure weekly collections of food waste for every household – restoring weekly collections in some local authorities introduce a deposit return scheme, subject to consultation, to increase the recycling of single-use drinks containers including bottles, cans, and disposable cups filled at the point of sale
- introduce annual reporting of food surplus and waste by food businesses. Should progress be insufficient, consultation on introducing mandatory targets for food waste prevention will be triggered.

A new survey published by the Food Safety Trust (FST) Tracker shows food safety was the third most important food issue for British adults, after value for money and the healthiness of food. The survey, which used a representative sample of 2,007 adults in England, Wales and Northern Ireland, found the top food safety issues of concern for those surveyed were:

- Food hygiene when eating out (35%), Food poisoning (29%), Chemicals from the environment, such as lead, in food (28%), Food additives (28%).
- The top wide food issues of concern were: The amount of sugar in food (50%), Food waste (46%), Food prices (46%), Animal welfare (43%).

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The general trend for concern about food safety in restaurants and shops has decreased since the first survey was carried out.

Most (84%) respondents were aware of the hygiene standards in place they eat out at or buy food from. The most common ways of knowing about hygiene standards were via hygiene stickers/certificates (82%) and the general appearance of the premises (60%).

The FSA has published the results of a Biopreparedness Trust study to identify the top food safety issues of public concern. Interviews were conducted face-to-face in November 2018 with a representative sample of 2,007 adults in England, Wales and Northern Ireland.

The Government is also investing £20m to tackle plastics and boost recycling: £10m more for plastics research and development and £10m to pioneer innovative approaches to boosting recycling and reducing litter, such as smart bins. This is in addition to the £20m for plastics research and development through the Plastic Innovation Fund announced in March 2018.

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**Circular economy for plastics**

An alliance of global companies from the plastics and consumer goods value chain has launched a new organisation to advance solutions to eliminate plastic waste in the environment, especially in the ocean. The cross value chain Alliance to End Plastic Waste (AEPW), currently made up of nearly thirty member companies, has committed over $1bn with the goal of investing a further $1.5bn over the next five years to help end plastic waste in the environment. The Alliance will develop and scale-up solutions that will minimize and manage plastic waste and promote solutions for used plastics by helping to enable a circular economy. The Alliance membership represents global companies located throughout North and South America, Europe, Asia, South America, Africa, and the Middle East.

The Alliance is a not-for-profit organisation that includes chemical and plastics manufacturers, consumer goods companies, retailers, converters and waste management companies, for example, BASF, Berry Global, Dow, DSM, Procter & Gamble, Shell, Total, Toyota, and others, also known as the plastics value chain. It has been working with the World Business Council for Sustainable Development as a founding strategic partner. Chairman of the AEPW and President and CEO of Procter & Gamble, David Taylor, described the new alliance as the most comprehensive effort to date to end plastic waste in the environment and urged other companies to join. He defined plastic waste as a complex and serious global challenge that requires collaborative action, partnerships and strong leadership.

An initial set of projects and collaborations has been announced that reflect a range of solutions to help end plastic waste:
- **Partnership with cities to design integrated waste management systems in large urban areas where infrastructure is lacking, especially those along rivers, which transport vast amounts of unmanaged plastic waste to the ocean.** This will include engaging local governments and stakeholders, and should generate economically sustainable and replicable models that can be applied across multiple cities and regions. The Alliance will pursue partnerships with cities located in high plastic leakage areas and will aim to collaborate with other programmes working within cities, such as Project STOP in Indonesia.
- **Developing an open-source, science-based global information project to support waste management projects across the world.** The data collection, metrics, standards and methodologies to help govern companies and investors focus on and accelerate actions to stop plastic waste from entering the environment. The Alliance will work with partners and organisations already involved in similar types of data initiatives.
- **Creating a capacity building collaboration with intergovernmental organisations, such as the United Nations, to conduct joint workshops and training for government officials and community leaders to help identify and pursue the most effective and locally-relevant solutions in the highest priority areas.**
- **Supporting the Renew Oceans Network to aid localised investment and engagement.** The programme is designed to capture plastic waste from the ten major rivers shown to carry the vast majority of land-based waste before it reaches the ocean. The initial work will support the Renew Ganga project, which has also received support from the National Geographic Society. In the months ahead, the Alliance will make additional investments and drive progress in other global regions.
- **Infrastructure development to collect and manage waste and increase recycling.**
- **Innovation to advance and scale new technologies that reduce, recover and recycle plastics easier and create value from all post-use plastics.**
- **Education and engagement of governments, businesses and communities to mobilise action.**
- **Clean up of concentrated areas of plastic waste already in the environment, particularly in rivers that carry land-based plastic waste to the sea.** Research from the Ocean Conservancy shows that nearly 80% of plastic waste in the ocean begins as litter on land, the vast majority of which travels to the sea by rivers. One study estimates that over 90% of river borne plastic in the ocean comes from 10 major rivers around the world – eight in Asia, and two in Africa. Sixty percent of plastic waste in the ocean can be sourced to five countries in Southeast Asia.

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**Food loss hotspots**

Human errors caused by a lack of standardized procedures and insufficient training are major drivers behind loss in food manufacturing, a new study has found. The research, conducted at University London and Ghent University, Belgium, studied the production process results for 47 food manufacturers in Belgium to determine what the highest losses were observed.

They found that human error accounted for 10.9% of all food waste, second only to the losses (13%) recorded as a result of product change (changing the food output of a manufacturing facility). A further 8.7% was attributed to product defects and 6.4% as a result of buyer contracts. The team also identified the relationship a company has with its suppliers and customers as being an area of significant key, especially when considering seasonal goods.

The researchers gathered data from a wide variety of companies, ranging from ready-meal manufacturers producing nearly 130,000 tonnes of products per year to drinks manufacturers producing nearly 500,000 tonnes of food for every 35 tonnes they produce.

Many manufacturers – particularly the smaller ones – were unaware of how much food they were wasting as they did not measure what was thrown away. They were surprised to see how much they were losing in monetary terms.
FROM THE CHIEF EXECUTIVE

Jon Poole
Chief executive, IFST

In 1977, the now late IFST Past President, Tom McLauchlan, bequeathed to IFST his rich and fascinating collection of more than 500 books and publications dating from the 1820s through to the present day. Over the last year we have been using the services of an archivist, Sheila Mercejea, to accurately catalogue and assess the collection. This collection currently resides in my office and so I have been conscious of some of Sheila’s exciting finds as she works through the collection. Quite recently Sheila came across several hundred post-World War II UK Ministry of Food pamphlets and regulations – the Ministry of Food (1939–1945) was a separate department from the Ministry of Agriculture and oversaw the World War II rationing programme.

Some of these pamphlets make fascinating reading and, whilst this may seem a big leap, I couldn’t help but make a link with some of the potential food supply issues we could be addressing in the very near future, if faced with a no-deal Brexit.

Topics covered by these pamphlets included surveillance – especially relating to black market activities – inevitable given the extreme shortages of food at that time. Licences to sell produce had to be obtained for a fee from the Government. Infringements were tried in licenced and unlicenced transactions, incurred fines.

Another topic concerned the transportation of food, with an emphasis on all transportation of food for domestic use and not for export. Even at that time, the Government was concerned about sustainability with trades people expected to follow the Ministry’s guidance concerning the reuse of returnable transportation containers.

Food Science and Technology had predominantly been forward-looking. But sometimes, it can help to at least consider the past to help inform our future thinking. Of course, I sincerely hope that, in the coming weeks and months, we do not find ourselves in anything like the situation our families did at the end of the War. We will be reporting in more detail on the McLachlan Collection in a future issue of Food Science & Technology.

**Belfast to host CHRO19**

The 20th Campylobacter, Helicobacter and Related Microorganisms Conference

We are pleased to announce that IFST Northern Ireland Branch is hosting CHRO2019, the world’s leading international conference on Campylobacter, Helicobacter and related microorganisms between 8 and 11 September 2019 in Belfast.

This international workshop will feature presentations by international and local experts reporting their most recent scientific updates and will provide the opportunity to meet, listen to and interact with world-class experts in the areas of scientific and clinical research, public health and industry, including Nobel Prize winner, Robin Warren.

**For more information and to book your place, please go to [IFST](http://ift.org/events/chro-2019-20th-campylobacter-helicobacter-and-related-microorganisms-conference).**

**Updated IFST Information Statements**

As part of our commitment to provide relevant and clear science-based information about food science and technology, we have published a new Information Statement on Bisphenol A. We have also updated our Information Statements on Nanotechnology, Bovine Spongiform Encephalopathy, Stevia, Food Authenticity and Dietary Fibre.

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

**For more information, please visit [IFST](http://ift.org/resources/resource-search?field_resource_categories=185).**

Nutritional Science over Gut Feel is the title of this year’s Spring Conference 2019 (SC19), which will take place on 4 April 2019 at the University of Birmingham. We have a stimulating programme with the highest quality line-up of speakers. We will explore the very latest scientific and technological research and innovation that is informing our thinking in tackling some of the biggest nutritional and health challenges, including obesity.

**IFST Spring Conference 2019 (SC19)**

**Confirmed speakers include:**

- Prof. Judith Buttriss, Director General, British Nutrition Foundation
- Prof. Petra Klassen-Wigger, Head of Nutrition, Health & Wellness, Nestlé Research
- Judith Robinson, Head of Health – Product Division, Tesco
- Prof. Jeff Brundstrom, School of Psychological Science, University of Bristol
- Prof. John Mathers, Director of Human Nutrition Research Centre, Newcastle University
- Dr Maria Traka, Deputy Head of Food Databanks National Capability, Quadram Institute
- Prof. Jonathan Napier, Flagship Leader, Rothamsted Research
- Dr Peter Mills, Assistant Director, Nufield Council on Bioethics
- Prof. Lisa Motihren, Sensory Science Centre, University of Reading
- Prof. Helen Griffiths, Executive Dean, Faculty of Health & Medical Sciences, University of Surrey
- Lucinda Bruce-Gardyne, Founder, Genius
- Dr Rob Winwood, Vice Chair, Council for Responsible Nutrition (CRN) UK and Manager, EMEA Nutrition Science and Advocacy, DSM Nutritional Products
- Céline McNamara, CEO, Creame Global

**For more information and to book your place, please visit [IFST](http://ift.org/events/SC19).**

Save on Food and Drink Good Manufacturing Practice

We are pleased to announce that the new edition of Food and Drink Good Manufacturing Practice (GMP 7) is now available.

This 7th edition has been completely revised and updated to incorporate take account of relevant developments in EU and UK legislation. It is a must-have guide for anyone in a managerial or technical capacity concerned with the manufacture, storage and distribution of food and drink.

IFST members receive 50% off the RRP.

**For more information, please go to [IFST](http://ift.org/our-resources/publications/food-and-drink-good-manufacturing-practice).**
Recent highlights in food safety and nutrition from IJFST

Inactivation of Listeria innocua using electron beam irradiation

As a non-thermal sterilisation technology, electron beam irradiation (EBI) has attracted great interest for microbial inactivation in food preservation. This study aimed to investigate the effects of EBI on membrane permeability, physiological status, morphological structure, genome integrity and protein structures of L. innocua irradiated at doses of 0.75, 1.50, 2.25, 3.00, 3.75 and 5.00 kGy. The results showed that EBI noticeably reduced the total microbial counts of L. innocua by more than 7 log CFU mL\(^{-1}\) with 5.00 kGy treatment. The cell membrane permeability increased, resulting in the leakage of intracellular substances and change in cell physiological status, which was proven by the cell staining and electron microscopy (EM) observations. Moreover, the integrity of genomic DNA and protein secondary structure, but not the protein primary structure, were disrupted. These findings provide the intrinsic mechanisms for the inactivation of L. innocua by EBI, which could serve as a theoretical basis for a better application of EBI in food sterilisation.

Shi et al., 2018, doi.org/10.1111/ijfs.14081

An improved detection method for tyramine in foods

Tyramine is considered a biological hazard for foods and beverages. In this study, an ultra-high pressure liquid chromatography (UPLC) with benzylamine as an internal standard in dazocil chloride pre-column derivatisation was developed to determine tyramine in various foods. The limits of detection and quantification of this method were 0.05 and 0.25 mg L\(^{-1}\), respectively, while the relative standard deviations of repeatability and reproducibility were 2.1% and 3.1%, respectively. The sensitivity and reliability were also evaluated by determining tyramine in common liquid, pasty and solid foods. The recoveries of tyramine in these foods were between 87.3% and 98.8% using this method. Overall, it is a fast, inexpensive, reliable and sensitive method to measure tyramine in different food products.

Zhang et al., 2019, doi.org/10.1111/ijfs.14141

The future of functional foods

Consumption of functional foods suggests a strategy to reduce the incidence of chronic health disorders. This message has resonated with consumers and driven market growth. Functional food research has significantly increased over the last decade but few studies have addressed the bioavailability of active ingredients for clinical efficacy. Baked goods, such as bread, biscuits and cake, are popular categories for innovation due to their widespread consumption. These new developments have often impacted organoleptic properties of finished products and thus consumer acceptance. Blending of bioactive ingredients may overcome this deficit. However, an understanding of the role of the microbiome in health has indicated that the efficacy of functional foods is unlikely to be uniform within the population. Further growth in the functional foods market, is likely to require greater evidence of the bioavailability of active ingredients, clinical effect and support for health claims by regulators, especially in the EU.

Bird and Bonwick, 2018, doi.org/10.1111/ijfs.14062

Reducing oxidation of dietary lipids

Processed foods are popular and their consumption is expected to grow globally. Food processing and manufacturing promote lipid oxidation in foods rich in polyunsaturated fatty acids and cholesterol. This review focuses on how various food manufacturing/processing techniques promote lipid oxidation in grains, meats and meat products, dairy and fats/oils. It also considers emerging evidence from animal and human studies that suggest a link between dietary oxidised lipid consumption and chronic disease risk.

An update in novel food technologies that limit lipid oxidation is discussed to encourage both food scientists and dieters/nutritionists to direct future efforts towards not only continuing to bring these novel technologies to the market place but also conducting clinical trials to establish their role in human health.

Jackson and Penemutela, 2018, doi.org/10.1111/ijfs.14058

Members

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Ensuring a secure and trusted supply of British food post-Brexit

Shraddha Kaul, of the British Poultry Council highlights the problems facing the poultry industry in the event of a no-deal Brexit or failure to secure a free trade agreement with the EU.

Trading with the EU

Britons prefer chicken breast meat to dark cuts like wings, legs and thighs. Ensuring a continuation of trade with the EU is essential to balance the carve. The sustainability of the industry is very dependent upon finding a market for 75% of the bird that is left over after removing the breasts. Absence of markets for these products, highly desired in some countries, pushes more value into UK-consumed breast meat.

If the UK reverts to WTO rules, it would result in additional trade friction costs of 8%, with the introduction of new checks to ensure regulatory equivalence that would create significant delays. If the UK fails to secure a free trade agreement with the EU and/or unilaterally remove tariffs for all trade partners, there is a danger that UK consumers will be faced with a lowering of standards and poorer quality food with imports from non-EU states.

No-deal Brexit will create a two-tier food system

Leaving the EU without a deal would be catastrophic for our sector, for our workforce and for British consumers of poultry meat. We risk losing the 22,800 EU nationals employed by our sector, the £5bn Gross Value Added. We contribute to the economy and the £1bn in tax revenue we generate.

In the event of a no-deal Brexit, there will be increases in the costs of production, which would be reflected in the price of fresh UK chicken. We estimate in the worst case no-deal scenario, the price of breast meat could rise by 25%.

If the Government is serious about making Brexit work, then it must avoid running the risk of creating a two-tier food system, where only the affluent can afford to eat British poultry that meets British standards from farm to fork.

It is crucial that the UK finds a workable trade deal with the EU and gives our sector access to the non-UK labour that we need to feed the nation. Government must treat food as a special case to ensure a secure and trusted supply of British food at a time of great uncertainty.

References and article available online at:
fstjournal.org/features/33-1/poultry-post-brexit

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Food safety culture is still a relatively new concept in the food industry but has been gaining traction recently as its impact on the success of food safety management systems, procedures, and practices has become clearer. Understanding the importance of culture in food safety performance follows several decades of food safety evolution. Starting with control systems based on analytical test results, the industry has progressed through application of hygienic practices and preventive HACCP-based FSMS (Hazard Analysis and Critical Control Point-based Food Safety Management Systems). This has led to the current appreciation of the role of human factors and organisational culture. Yet food safety culture can still seem a ‘fuzzy concept’ that is difficult to grasp. Measuring how good yours is and how to improve and benefit from a strong food safety culture can be a challenge.

Looking more closely at the evolution of food safety and some of the limitations of previous and current food safety management programmes helps to demonstrate why we need to pay attention to food safety culture today (Figure 1). It is well known that HACCP was developed as part of the food supply project for the US manned space programme and that the concept was launched publicly to the food industry in 1971. Early in its development, HACCP was reported as an effective and economical way to prevent foodborne disease and this contributed to the international acceptance of the HACCP principles, their adoption in regulations, such as EU 852/2004, and their role as a cornerstone of food safety management programmes. As shown in Figure 1, the food industry’s journey with HACCP really started in the 1990s and usage grew through the 1990s and 2000s as more companies and stakeholders recognised its value. During this period, the international agreement on the Codex HACCP principles was published and the key role of prerequisite programmes or good hygienic practices working hand in hand with HACCP was recognised. Modern HACCP-based food safety management systems have come a long way since the early days, but food safety remains a key public health challenge.

Theoretically, effective HACCP-based food safety management programmes should ensure that food remains safe throughout all stages of the global food supply chain. However, food contamination outbreaks and incidents continue to occur, even in large businesses. For example, foodborne illness outbreak data reported in the EU in 2015 showed a total of 4,362 foodborne outbreaks, causing 45,874 cases of illness, 3,892 hospitalisations and 17 deaths across 26 EU Member States. This demonstrates that HACCP systems are not always working effectively in practice, a view echoed through analysis of third party audit data, and...

Figure 1 Evolution of Food Safety Management Systems and Culture © Carol Wallace, 2018
that HACCP-based FSMS alone are insufficient. It has long been a longstanding personnel working in food operations are key to food safety success\(^{17}\); but it is through more recent work that the role of culture has come to the forefront (Figure 1).

Retropective investigation and analysis of foodborne illness data has identified employees’ food related work behaviour as well as other human factors and food safety culture as critical contributors to food safety risk factors in food outbreaks\(^{18}\). Thus, the concept of culture has been recognised as important to food businesses’ efforts to consistently produce safe food and all food safety systems and practices are now understood to operate within and be heavily influenced by the prevailing food safety culture of the organisation (Figure 2).

Food safety culture builds on work from the earlier fields, including organisational culture, psychology, human factors research, safety science and culture, social cognitive science and national culture. These are well developed fields in their own right and they demonstrate that, like HACCP, food safety culture needs multidisciplinary input from a range of perspectives. In this case involving disciplinary specialists, such as social scientists, psychologists and behavioural specialists, working alongside food safety specialists.

Understanding food safety culture

Food safety culture is generally described as the interlinking of different theoretical perspectives: organisational culture, food science and social cognitive science.\(^{19}\) Organisational culture concerns the shared values, beliefs and norms that influence how employees think, feel and behave towards each other and towards situations facing the organisation.\(^{20}\) Food science refers to the definition and quantification of food safety risks associated with a given product and process and social cognitive science can define, measure, and predict human behaviours. Thus, working together, all of these perspectives are important in understanding food safety culture. Several definitions have been proposed for food safety culture, the simplest form of it is ‘the way we do things around here’\(^{21}\). A more detailed definition is that food safety culture starts to break down its elements, e.g., shared values, beliefs and norms that affect mindset and behaviour towards food safety in, across and throughout an organisation.\(^{22}\) Thus, in reality, food safety culture is a multi-layered concept, with elements that are hidden below the surface, and this is what makes it difficult to measure as it cannot be easily monitored using traditional food safety methods.

In order to effectively measure food safety culture, it is important to be able to break it down and understand its different elements that make it up. Key work on this was undertaken by Jepersen et al.\(^{23}\) in understanding the content of eight organisational and food safety culture evaluation dimensions, investigating what they mean, how they drive and looking at their commonalities and differences across the different systems. This resulted in a proposed framework of five dimensions of food safety culture (Figure 3). The dimensions are:

- **Dimensions of food safety culture**
  - **Values and Mission** includes management and employee commitment to food safety, how the leadership sets direction for the organisation, including objectives for food safety, and how leaders motivate staff around food safety. In addition, the perceived value and priorities towards addressing food safety and food safety ownership sit under this dimension.
  - **People Systems** includes aspects, such as knowledge, qualifications and training, pertaining to food safety and risk. Integration of new employees and expectations of competency levels, team effectiveness, expectations of tasks or behaviours, communication between leaders and employees around food safety, and actual and expected involvement, accountability and degree of team member input.
  - **Adaptability** looks at how the organisation either embraces or resists change as well as how food safety problem solving is approached. Consistency including degree of role following and enforcement of systems requirements is important as well as by-passing of requirements. Elements that support the achievement of good consistency include having good processes, instructions in place, access to the right tools and technology to enable behaviour and investment in infrastructure. Risk Appetite section includes whether risks are known and under control, as well as whether employees are aware of potential food safety risks.

These dimensions were all found to a greater or lesser extent in all the organisational food safety culture measurement systems assessed\(^{24}\) and have since been accepted by industry stakeholder groups\(^{25}\). In this way the dimensions are providing a road map for what to measure in order to understand food safety culture.

Current initiatives

Over the last 5-10 years much research has been ongoing to try to understand food safety culture and how it impacts food safety performance. There are still many questions to be answered but studies demonstrate that businesses with more mature food safety cultures demonstrate better food safety performance\(^{26-28}\) and maturing and strengthening food safety culture can impact profitability\(^{29}\). Progress is facilitated by networking of academic and practitioner groups and key current initiatives include:

- **Salus, the Food Safety Culture Science Group** was formed in 2015 and is a group of researchers with interests in understanding the workings of food safety culture and its role in the provision of safe food. Salus members are passionate about delivering underpinning rigour to practical solutions that drive and strengthen food safety culture. Recognising that collaboration is critical to progress an expert certification body auditors will not be auditing food safety culture per se but will be looking at how businesses are planning, monitoring and reviewing their food safety culture on an ongoing basis.

Improved knowledge and best practice sharing is helping businesses to visualise and improve their food safety cultures.

**General Principles of Food Hygiene (CIC: 1990) and HACCP principles annex were opened for review following the 46th meeting of the Codex Committee on Hygiene. This process is still ongoing, however, food safety culture is also included as an important feature in the draft documents. Food business operators and all relevant stakeholders need to take a lead on the evolution of the hygienic practices and food safety systems of the future. The Codex document to cultivate a strong food safety culture by demonstrating their commitment to providing safe and suitable food and encouraging appropriate food safety practices.

- The International Association for Food Protection (IAFP) created a Professional Development Group on food safety culture in 2017. Its mission is to provide an international forum to advance food safety culture science and best practices. The group has identified priorities of understanding and measuring food safety culture as well as identifying critical contexts in which organisations want to understand and strengthen food safety culture and the need to evaluate role in outbreaks and recalls. A workshop on the GFSI organisational dimensions was held at IAFP’s 2018 annual meeting, sharing best practices, successful tactics and roadblocks to progress. The group continues to look at knowledge sharing opportunities in 2019. These efforts by academics, stakeholders, and standards’ owners’ are helpful in advancing understanding of food safety culture and the need to lay down requirements for food businesses to understand and strengthen their food safety cultures.

Impact on food safety management

In summary, the impact of food safety culture and management systems is becoming better understood and improving food safety and best practice sharing is helping businesses to visualise and improve their food safety cultures. This will help to strengthen the application of food safety management systems and improve food safety performance.

Much focus so far has been on measuring culture, but this has been switching to ways of understanding and strengthening culture so that organisations can mature their food safety culture along with efforts to measure and strengthen food safety management systems. In order to drive this agenda forward, a toolkit of options will be needed depending on the status of the food safety culture in each business. This is likely to include a number of established and novel approaches within businesses:

- team building activities and training techniques;
- application of behavioural theories and interventions;
- clarification of vision and strategy and linking it to what leaders actually do and say;
- provision of necessary resources, systems and equipment to enable an effective culture;
- sharing of best practices.

In order to do this convincingly there is a need for both further research and the sharing of best practices. This means that it is essential that further academic, stakeholder groups continue to work together to improve knowledge and practice around food safety culture.

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[1] FSTDJOURNAL.ORG/issues/32/33/1

[2] Prof Carol A. Wallace, PhD, CSci, PGCE, FIPSN, FIIFST, FHEA, Professor of Food Safety and Systems, Co-Director, Institute of Nutritional Sciences and Applied Food Studies.

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[6] Food safety management systems are also known as improving and strengthening food safety culture so that organisations can mature their food safety culture along with efforts to measure and strengthen food safety management systems.
Training in food safety culture

The GFSI Food Safety Culture Position Paper[1] defines food safety culture as ‘shared values, beliefs and norms that affect mindset and behaviour toward food safety in, across and throughout an organisation’. Food safety is a shared responsibility and all employees have a role to play. Employees, irrespective of their position within the company, need to understand how their actions can have an impact (positive or negative) on food safety. To ensure the right behaviours at all times, each employee needs to have been trained properly; they need to know exactly what is expected of them, what the right thing to do is, how to do things right and crucially what the consequences are to them directly.

Companies also need to bear in mind that training is one of 20 dimensions that they need to address to drive a strong food safety culture as described in the GFSI position paper and in the Culture Excellence model[2] (see Figure 1). So, in the case of a near miss or incident, it is critical to carry out a thorough root cause analysis to determine the real reasons why the person behaved in that way; far too often, we see ‘re-training’ as the sole corrective action.

Bertrand Emond, Head of Membership & Training at Campden BRI, explains how companies can achieve excellence in food safety culture training programmes.

As part of Campden BRI’s work supporting companies with their food safety culture excellence programmes, it is clear that many struggle with ‘training’ as HR staff are typically not as engaged as they should be and not providing enough support to the technical functions within the food safety training activities. The most common feedback received includes:

- Training is not effective and has no direct impact on behaviour
- Training is not frequent enough and refreshers are late
- Training is not perceived as enjoyable and worthwhile
- Training has no clear and measurable objectives
- Perception of what constitutes training varies
- There is no robust training needs analysis across the organisation
- The competency/capability framework is non-existent or sketchy

This is quite worrying as corporations and individuals need to learn new knowledge and skills quickly and need to be able to apply them effectively. High quality training is essential to ensure that employees are competent.

In order to make the food safety training as effective as possible and to optimise the transfer of skills and knowledge, an organisation needs to get the following basic elements right:

**What and to whom**

What is covered during the training session has to be pitched at the right level for the intended participants, you need to be clear what level of proficiency you are hoping to achieve – ranging from basic awareness to an expert able to train others! The content has to be relevant and as specific as possible to the participants’ roles and responsibilities to ensure they are competent, qualified and confident to perform their jobs. They also need to be able to use the new knowledge or skill as soon as possible after the training session, otherwise they are highly likely to forget most of it very quickly.

When it comes to food safety, it is a shared responsibility and all parts of the organisation have a role to play. Senior leaders and support functions, such as procurement, logistics and finance, tend to be forgetful. They all need to have at least an awareness of the food safety risks and hazards affecting their business and be clear on their responsibilities to ensure food safety is not compromised by one of their actions.

A common area which needs improvement is the time and resources dedicated to enrolling/induction of new employees and training of agency/temporary staff. No employee should be allowed to carry out work without having completed the necessary training or induction and without having the confidence of knowing what is expected of them and what their accountability and responsibilities are.

Unfortunately, far too many companies are under huge commercial pressure and choose to compromise on this. A competency framework needs to be established to define the knowledge, skills, abilities and behaviours that members of staff at all levels need to perform their food safety roles effectively. To ensure that the roles are well understood and defined, it is good practice to get input from the job holder, supervisors and also HR. The benefits highlighted by businesses who have adopted these frameworks include:

- Employees are clearer on what is expected of them
- Clearer accountability across the organisation
- More effective recruitment and new staff selection
- More effective performance evaluation
- More efficient identification of skill and competency gaps
- Helps provide more customised training and professional development
- More effective succession planning
- More efficient change management processes

**How**

How the above content is delivered needs to be adapted to the intended recipients taking into account demographics, such as literacy level, language, cultural and generations variation, learning preferences. Spaced short focused and engaging/interactive sessions seem to be more effective than a one day cramming course. Some companies have developed great training materials purely based on pictures to address literacy and language related challenges.

Training should include a range of learning opportunities, such as education, experience on the job, coaching and mentoring, networking, workshops and conferences, job shadowing, etc. – not just the dreaded PowerPoint, classroom, once a year talk or 15 mins on a computer clicking through slides ‘sheep dip’ approach!

A blended approach combining face to face activities and online learning has been adopted by a growing number of businesses as well as interactive training systems, gamification and micro-learning. There are some very exciting computer technology developments, which help to make training adaptive, personalised, interactive, engaging, fun and memorable, including augmented reality, virtual reality, alternate reality computer games, wearables and smart goggles that enable expert remote assistance (as and when needed) and also enable remote on the job training and competency assessment.

Well-designed assessments, e.g. quizzes, surveys, tests, exams, projects/assignments, are great tools to support learning (by providing search and retrieval practice), minimise forgetting, confirm skills, knowledge and behaviours and motivate people by giving them a sense of achievement and confidence (through the results and feedback received). The types of assessments used will obviously depend on the target level of proficiency and expertise and need to be relevant and proportionate.

There are many benefits of asking questions. Questioning constitutes a form of repetition, which helps learning (especially if spaced over time for example).
FOOD SAFETY TRAINING

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Food-safety-training

fstjournal.org/features/33-1/
available online at

References and article available online at:
http://fstjournal.org/features/33-1/food-safety-training

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Where

The location needs to be conducive to learning, free from distractions and comfortable in terms of light, temperature, facilities and space with refreshments available if needed.

Why

This is key and many businesses keep missing this one. It is essential that the individuals understand why they are getting this training, why it is important, and what the success evaluation criteria will be.

They should be prepared and there should be a sense of accountability for using the new knowledge and skills. It is equally essential that the work environment supports the use of knowledge and expertise so peers and supervisors/managers need to understand the role they have to play as part of this training, including support, feedback and coaching.

It is widely acknowledged that people’s food safety behaviour is significantly influenced by their supervisor/manager’s commitment and attitude towards food safety.

Learning activity needs to be complemented by regular messaging and communication, including for example regular campaigns focused on specific food safety topics (e.g. hand washing week, cross contamination day), signs and posters located in relevant areas, reward/incentive/award/recognition programmes, supervisor/shift huddles, videos, reminder of consequences of not doing the right thing, social network and messaging (e.g. WhatsApp, Yammer).

Effective training is a key component of a strong food safety culture and companies with successful programmes of staff training and continuing professional development (CPD) report many benefits including:

• Increased job satisfaction and morale among employees
• Increased employee motivation
• Increased efficiencies in processes, resulting in bottom line benefits
• Increased capacity to adopt new technologies and processes
• Increased levels of innovation in strategies, products and processes
• Reduced employee turnover (due to the perception of being valued)
• Enhanced company image (resulting in the successful recruitment of higher calibre staff)
• Reducing risk (through training staff on a range of subjects from Food Safety and Hygiene to Traceability and Cultural Diversity).

Conclusions

There should be a clear management commitment to ensure that enough time and budget is devoted to training to do it properly. We need to do what we do better and smarter to optimise the return on investment and effort. We also need to keep in mind the following quotes:

“The only thing worse than training good employees and losing them, is not training your employees and keeping them” Zig Ziglar.

“If you think training is expensive, try ignorance and stagnation” Peter Drucker.

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Courage over comfort

The following facts are well known:
- We continually see trusting consumers get sick or lose their lives from eating food;
- Many of these tragic cases could be avoided and are often related to human assumptions and errors;
- Up to 54% less errors happen in strong cultures;
- Cultural maturity impacts the cost of delivering food quality, which can be as much as 22.5% of sales.

So, with this knowledge, we are not short of rational arguments for why change in food safety culture is required, but still the food industry is faced with some fundamental challenges like creating sufficient time for adequate and effective training. In order to implement a strong food safety culture, behavioral changes may be required.

Increased courage
After a training match, 20 times grand slam winner, $119m prize winner, Roger Federer, is stopped by Bill. Bill is a club volunteer, father of three, and working for the day to check that only those with the right badges are allowed into the players’ lounge. Roger does not have his badge on. Bill refuses him access to the lounge. Finally, Roger’s badge appears with a helper and he is let into the lounge by Bill, the club volunteer and badge checker for the day.

There could have been a number of different outcomes to this tennis story. Bill could have let the famous player in on face value. Roger could have raised his voice and insisted that he be let in. But neither reacted this way.

Bill put courage over comfort and managed the risk of anyone gaining unrightful access to the lounge. Roger put courage over comfort as he respected Bill’s role and the rules, he waited patiently for his badge to arrive. They both acted with integrity. Integrity is that magic glue that allows tough decisions to be respected despite position power or lack thereof.

Measuring and impacting integrity
Integrity in the food industry can be measured by use of social desirability rating or simply put ‘the prevailing willingness of team members in all roles to Walk the Talk’.

Dr Lone Jespersen discusses how to measure and cultivate safe behaviour in a food business.

Walking the Talk data gathered across 60+ companies in North America, Australia and Europe reveals three clusters with distinctive characteristics (Figure 1). Cluster #1 is characterised by teams that are less worried about their own image than food safety performance and always ready to speak up on risks.

Cluster #2
Tendency to overemphasise negative or positive and to answer in order to preserve image. There are mixed feelings about speaking up on risks.

Cluster #3
Worried about self-image and reluctant to give true answer regarding risks.

Figure 1 Walking the Talk clusters based on the Social Desirability scale. Jespersen et al, 2018
Using the example of Bill and Roger, Bill would be clear on expectations and empowered to act in accordance with those in cluster #1, less so in #2, and likely not at all in #3. Translating this to food safety in a manufacturing environment, it is the difference between a supervisor or frontline worker stopping the line in cluster #1 and not stopping the line in cluster #3. Alternatively, it could be an unsafe product not shipped to the customer vs. shipped to the customer.

**Driving impacts**

Many factors can be responsible for driving food safety impacts, depending on whether a food safety culture is in cluster #1, #2, or #3. Two important factors can be identified in the scientific field of sociology: consequences and recognition.

**Consequences**

Braksick et al. brought forward the seemingly simple sociology model of the ‘ABC’ (Figure 2): The theory shows how antecedents (A) influence behaviour (B) but not as much as consequences (C). Antecedents are all the tools in our box that help us gain an understanding of what is required of us, e.g. training, standard operating procedures, job descriptions, stimulus, policy, stated expectations, job aids, circumstances, events and past experience. Consequences, on the other hand, are the feedback we gain from our actions, e.g. mention in the CEOs weekly message, salary increase, peer award and a simple thank you. Braksick argues that many companies spend up to 80% of their effort on ‘A’ and 20% on ‘C’, when in fact, from a social-psychology perspective, ‘C’ impacts 80% of why we behave in a certain way against 20% for ‘A’. It is not difficult to see how cluster #1 drives the desired behaviours by overemphasising ‘C’ in a strategic and planned manner.

**Recognition**

Another factor that impacts a person’s willingness to put courage over comfort is recognition. The Work Human Institute of Gishofore conducted a study in 2017 to quantify the impact of leaders recognising employees and the employees’ trust in their leaders. They found that recognition not only increased trust (from 34% to 82%), depending on leaders’ habits of recognising their employees, but also that in those companies where leaders showed strong recognition of employees, there was 50% less turnover of staff.

**Actions to put courage ahead of comfort**

We need to embrace the thinking of organisational psychologist Gary Klein, who has researched extensively on what makes us discover new solutions (Figure 3). Klein defines one end of the continuum as ‘stupid’, where organisations and individuals are gripped by flawed beliefs, there is a lack of experience and a passive stance is taken to the status quo. At the other end of the continuum, we find organisations which have escaped the fixation on flawed beliefs, have more experience and take an active stance. By recognising this continuum, you can decide whether your organisation’s food safety culture is driven by stupidity or insights and choose to take action accordingly.

**Conclusions**

Food businesses should encourage their employees to walk the talk and hold people accountable for walking the talk. Staff should recognise the food safety behaviour of others and actively manage the consequences – positive and negative. As a team you can ensure your organisation’s culture of food safety is assessed and that there is a linked or integrated plan to drive change.

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**Figure 3 Getting started to discover new solutions**

**Figure 2 ABC behavioral model**

**References and article**

Food Safety Behaviour

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Certifying food safety culture

A culture of food safety

Food safety culture has become the Zeitgeist of the food business world. It is increasingly recognised that the most significant challenge for food businesses is to introduce a positive culture of food safety into their operations and create a behaviour-based Food Safety Management System (FSMS). The safety culture of a food organisation is the product of individual and group values, attitudes, competencies and patterns of behaviour that determines the commitment to and the style of proficiency of an organisation’s food safety programme. Food safety culture is governed by the behavioural science of individuals and teams and how they are conditioned by their working environment. Every food business large or small has a safety culture, be it positive or negative and whether it is recognised by the organisation or not.

Most food businesses have comprehensive and prescriptive rules for food safety practices. The challenge is to ensure that they are being followed at all times, regardless of the situation. This is where culture and understanding behavioural drivers plays an important role. For example by using techniques from nudge theory to make safe behaviour habitual and ingrained. Training on its own can give a false sense of security. Trained food handlers can still demonstrate a dangerous gap between their knowledge of food safety handling practices and their application of these principles in the workplace. Just because food handlers know why they should follow a practice does not mean they will do so. Only by understanding and influencing food handler behaviour will we be able to embed food safety in an organisation’s culture and drive behavioural improvement. A strong food safety culture will ensure that good practice is not only understood but also, more importantly, being followed. Real food safety culture is what happens when senior leaders, managers and supervisors are not present and individuals are left to their own devices. Food safety must be embedded in the business values. Priorities may well change in an organisation depending on the circumstances but values do not.

Effective management of behavioural interactions is essential to develop positive attitudes to drive food safety.  

The Global Food Safety Initiative

The Global Food Safety Initiative (GFSI) is the pre-eminent food industry programme, which provides leadership, guidance and harmonisation on food safety management systems across the global food supply chain. Since its inception in 2000, GFSI has brought together stakeholders representing the global food industry to collaborate on advancing food safety. Its mission is to deliver continuous improvement in FSMSs to ensure confidence in the delivery of safe food to international consumers.

In 2018 the GFSI produced a high profile position paper in which it defines food safety culture as ‘shared values, beliefs and norms that affect mindset and behaviour toward food safety in, across and throughout an organisation.’ This has elevated the visibility of food safety culture and has given it an important stamp of approval and credibility, signalling a clear message to the supply chain of the importance of the business safety culture in maintaining food safety standards. The GFSI position paper is broken down into five dimensions (Table 1). Each dimension explains in practical terms the importance of advancing a culture of food safety. It has been developed to help food organisations strengthen and maintain a positive and mature food safety culture and to protect global consumers. This paper will help food organisations structure, analyse and assess their progress.

Table 1 The GFSI position paper on culture of food safety is broken down into five dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
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<tbody>
<tr>
<td>Vision and Mission</td>
<td>Communicates a business’s reason for existence and how it translates this into expectations and specific messaging for its stakeholders.</td>
</tr>
<tr>
<td>People</td>
<td>Are the critical component of any food safety culture. The way we act and interact in our work is the way we develop in our organization.</td>
</tr>
<tr>
<td>Consistency</td>
<td>Refers to the proper alignment of food safety principles with requirements on people, technology, resources and processes to ensure the consistent and effective application of a food safety programme that reinforces a culture of food safety.</td>
</tr>
<tr>
<td>Adaptability</td>
<td>Refers to the ability of an organisation to adapt to changing influences and conditions and respond within its current state or move to a new one.</td>
</tr>
<tr>
<td>Hazard and Risk Awareness</td>
<td>Differentiates food safety culture from the broader organisational culture. Recognising actual and potential hazards and risks incidents, all levels and functions, represents a key element to building and sustaining a food safety culture. Basic scientific and technical information should be accessible and understandable to everyone. As a company, it is important to keep current on the latest industry intelligence including market incidents, changes to food safety legislation, significant new technology and analytical advances. This will broaden awareness and understanding of potential risks and hazards.</td>
</tr>
</tbody>
</table>

BRC Global Standard for Food Safety

The leading GFSI-recognised certification programme in the UK is the BRC Global Standard for Food Safety, with over 26,000 certified suppliers in over 130 countries. Recently there have been a number of high profile food safety incidents reported in the media from sites with satisfactory BRC audit scores, indicating that the system needs to be improved. One of the responses of BRC to further strengthen the standard has been to include food safety culture in the new Global Standard for Food Safety Issue 9. It was published for public consultation in August 2018 with the first audits starting on the 1st February 2019. The main focus has been on the development of product safety and quality culture. It is the first GFSI-recognised food safety programme to include requirements specifically for culture.
Section 1 of Issue 8 covers Management Commitment. The new requirements state ‘The site’s senior management shall define and maintain a clear vision and strategy for the development and continuous improvement of food safety culture’. This shall include: defined activities involving all sections of the site that have an impact on product safety, an action plan indicating how the activities will be undertaken and measured, and the intended timescales, and a review of the effectiveness of completed activities.’

It is very important to recognise that it is not BRC’s intention to actually measure an organisation’s food safety culture. Instead it is encouraging sites to consider the importance of culture and the development and creation of plans of action and the evaluation of their success. These are measurable objective requirements that can be documented and audited. Auditors will not be attempting to audit the ethos of the site that will be borne out of the culture that they have implemented a food safety culture plan. Auditors will instead be probbing into more time with the food business in the field on their senior leadership and culture discussions with teams discussing the company’s organisational culture and how it is managed. As this is a completely novel concept, many sites will be concerned about how they will evidence this.

However, they should see this as the first step on a journey in which the food business in the field on their senior leadership and culture discussions with teams discussing the company’s organisational culture and how it is managed. As this is a completely novel concept, many sites will be concerned about how they will evidence this.

Culture Excellence Programme

In response to demand from its membership, Campden BRI (the UK’s largest independent membership based organisation for research and development in the food and drinks industry) has developed its own Culture Excellence Programme and Website to support food businesses. The Programme was launched in 2014 and includes assessment, analysis, reporting and ongoing support to food businesses. Campden BRI developed the Programme in partnership with Taylor Shonnon International (TSI).

The programme’s objective is to understand and improve a business’s food safety and quality culture. The participants in the scheme are assessed by an online anonymous staff survey broken down into four main areas (Table 2) with more than 500 individual scored data points. The programme is fully aligned with the GSFS approach. It is designed to capture cultural data and use it for continual improvement. A recent global survey by Campden BRI amongst its members found that technical managers found that the respondents placed food safety culture as the fundamental factor in delivering product safety.

Regulation

There are no requirements in UK food legislation relating directly to culture. However the Food Standards Agency (FSA) has developed a Food Safety Culture Diagnostic Toolkit in 2012 for implementation. This investigation tool is for the use of local authority personnel undertaking food hygiene inspections to help identify aspects of food safety cultures prevailing in food businesses and as a framework to influence business values.

Food businesses can adopt some of the tool’s exercises to help determine what level of culture exists in their organisation. This would have the added benefit of a shared nomenclature with inspectors.

For regulators, it can help to support enforcement decisions and the provision of advice. It is important to understand and categorise the ethos of a business by classifying food safety culture into a series of groups (Table 3). Food Standards Authority personnel could also have produced useful self-assessment tools with a guide to what good safety culture looks like. It is clear that successful and sustainable food safety must begin with its internal regulation. A behavioural based approach will help to maintain this investment.

The key requirements of UK food legislation, found in The Food Safety Act 1990, are to:

- ensure personal and company performance
- manage quality and the fight against fraud.8 Such certification is frequently a condition of trading for many food businesses and lack of certification can even be a barrier to entry into key markets, retail places, and often a fundamental requirement for leading brands, retailers, manufacturers and food service organisations.

The compulsory adoption of food safety culture standards by BRC will undoubtedly stimulate the global uptake of the behavioural-based FSMS approach. Other stakeholders, including shareholders, insurance companies and venture capitalists, are likely to influence uptake of the standard. These organisations are using culture as a measure of capability and reliability that can be translated into an improved financial position and the mitigation of risk. Legislators also increasingly recognise that successful and sustainable food safety must go beyond formal regulations. The current concept of culture is related to the global food legislation impacts food safety but ‘how’ it does and how best to achieve behavioural-based FSMS implementation and improvement. Food safety culture has come of age and by 2015 may be the year of delivery driven by the increasing need to meet customer requirements and standards. This will play a major role in ensuring confidence in the delivery of safe food to consumers.

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25 VOLUME 32 ISSUE 4
Wayne Martindale, Tom Hollands and Mark Swainson discuss recent advances in new product development (NPD) that use digital platforms to analyse a wide variety of data to achieve ‘meta-solutions’ that address all aspects of a product’s performance.

A changing landscape
The reality of a 21st century lifestyle is that we work and consume in a globalized food system that has raised living standards and increased longevity in regions where efficient food manufacturing and supply is possible. Improved nutrition is responsible for much of this and innovative manufacturing enables us to revolutionise how we develop new food products for improved quality, price and convenience. The resulting accessibility to food is not without its issues because eating more of what we enjoy means poor dietary choices can be made more often, resulting in increases in diseases, such as diabetes.

Getting new product development (NPD) right can help to tackle these problems by reformulation and the use of tools, such as nutrient profiling. NPD is getting smarter because we can begin to project how products are consumed at the population scale. Where NPD has been focused on the product and marketplace, we can increasingly project its impact in populations. NPD research is also crossing the manufacturing efficiency and consumer choice boundaries so that we can meet more sustainable outcomes at scale to react to consumption trends and at the same time maintain a responsibility to improve health. The result is a new meta-NPD approach, which has been enabled by digital technologies that dramatically scale existing methods. Meta-NPD provides an enhanced understanding of all available data about a product, including consumer preferences as well as quality, nutrition and sustainability.

The requirement to address the problem of poor dietary choices is compounded by critics of the food industry, who have recently called for a ‘rebooting of the food system’, a sentiment that does not resonate with the experience of food manufacturers. Clearly NPD practitioners must do more to connect with consumers. This article aims to demonstrate that tackling these criticisms requires rethinking how we communicate successful NPD of food products.

Understanding consumer choice
NPD will never stand still and food manufacturers need to be agile enough to respond to change so that they can deliver consumer choice alongside price, quality and nutrition – no single attribute is more important to the whole food value chain. Many manufacturers want to be more visible in communicating the integrity of foods because it increasingly determines the purchasing choice in a competitive retail arena, where price and quality are not as differentiated as they once were. Product quality systems mean that all manufacturers supplying retailers are able to show high value and quality, but a demonstrator for food integrity is more elusive.

During the 1990s British retailers mastered quality systems and category management to respond to our year-round demand for a wider range of foods, in particular fruit and vegetables. It improved the British diet by increasing the accessibility of different fruit and vegetable varieties to consumers, supporting the five savings a day recommendation for a healthy diet. It has also been shown that people who frequently cook at home maintain a healthier diet than those who cook less frequently, as the former consume fewer calories[1]. Understanding such trends is necessary for future NPD to move from a purely product focused exercise to the metalevel, where all available data about a product is considered. This approach takes into account consumer attitudes and choices as well as efficiency and productivity. It can help to explain why consumers are not responding to solutions provided by the supply chain.

Sustainability
Product developers must begin to take a long-term view for continuous improvement and this requires a step back initially to take stock of what successful product development means for consumers and their diet at a meta-NPD level. Developers will increasingly be asked to link the constraints of food product design with high level targets, such as the UN’s 17 Sustainable Development Goals that cross the health, social wealth and environmental lenses of sustainable food supply. The resulting options and trade-offs that emerge from considering such targets may lose sight of consumer experience. This is in part due to a lack of commercial direction coming from sustainability assessments. Of course, NPD is not all about sustainability, but this arena does provide a demonstration of how complex things can get.

Carbon footprinting provides case and point here. If sustainable diet was only concerned with providing low carbon outcomes, we would...
actively recommend a diet consisting of cake. This is because white sugar has one of the lowest carbon footprints per calorie. It is also produced in one of the most efficient manufacturing systems that makes use of crops, such as cane and beet, which are the plant world equivalent of Formula One racing cars because they convert sunshine into sugar exceptionally quickly[3]. An even more puzzling outcome of carbon footprint assessments is that we would not think of using anything but plastic for food packaging because, like it or not, when the life cycle of plastic is managed, it is environmentally benign[4]. This all flies in the face of consumer attitudes as consumers are increasingly isolated from the science of sustainability. NPD does not just work in terms of efficiencies of production – consumer choice has a far more important impact, which is often overlooked. This is why meta-NPD assessments are necessary to help reorient consumers with the food system.

Meat-free

The influence of projecting NPD to meta-NPD scenarios can be seen in the rise of meat-free choices, where complex sustainability trade-offs have been crystallised in the minds of consumers using terms familiar to them. ‘This has gone well beyond the simplistic “plant is good, meat is bad” choices of the past, because we have seen the emergence of redditorian and flexitarian lifestyles that were never expected. Understanding consumer demand for meat provides a testing ground to see how consumption trends establish themselves and are influenced by sustainability targets in a real FMCG (fast-moving consumer goods) marketplace. Much of the meat-free product market depends on growing protein using efficient sugar to protein conversions to provide laboratory grown alternatives. Sugar, with its lower carbon footprint per calorie, can provide the right margins to make the economics of meat-free to work. This will continue to be highly disruptive in the marketplace if the requirement to rationalise consumption of livestock products remains an important goal of global sustainability, because existing dietary inequalities are still very much defined by livestock consumption[5]. Research must continue to help consumers understand how diets can affect global impacts using rational science-based communications and the meat-free resurgence has done this exceptionally well at meta-NPD levels. Changing NPD and manufacturing practice must focus on guiding innovations to meet consumer choices[6]. This will shape how new products are experienced by consumers – sustainability has already begun to do this in the marketplace.

Consumer choice should be at the core of getting food product development right. A switch or nudge to more sustainable dietary options is not only possible, it has already happened for protein choices, where increases in the consumption of more ‘eco-friendly’ beans and lentils has occurred[7]. This would have been considered unthinkable not that long ago and it has been driven by consumer demand. Many NPD functions are trying to catch up with this shift in consumer attitudes. Meta-NPD modelling can help to make sure future activity leads rather than follows trends.

Innovation hot-spots

What becomes increasingly evident in transforming practice to a meta-NPD system is the need to consider all supply chain partners if innovation hot-spots are to be identified. An example of this has been the development of the ‘perfect’ sandwich. This demonstrates how meta-data coming from the consumer can provide long term solutions to improving quality and sustainability of products. The development of the perfect sandwich focused on consumer complaints associated with ‘lumpy’ sandwiches that are often the main source of a lack of fulfilment. The solution has come from an investigation of supply chain data from seed to consumption that has identified tomato varieties that do not release water so readily when they are sliced. The tomatoes selected were previously overlooked because they are typically used for pizza and not sandwiches. However, using those tomatoes resulted in a ten-fold reduction in waste associated tomatoes during manufacture and, most importantly, the finished product is not considered ‘lumpy’.

A similar approach has been used in the sandwich category for lettuce varieties that have been selected due to their ability not to brown after cutting. This all matters because it links procurement of ingredients to optimal NPD processes that provide complete product fulfilment. Projecting the success of a product is difficult but meta-NPD can help to guide the process towards a ‘success index’. This is far from straightforward, but it has been proven possible to address consumer tastes relating to tomatoes and lettuces in sandwiches.

Ingredient integrity

There is now a robust set of data that shows we can reduce consumer food waste close to zero for each meal if preservation methods are used.

Conclusions

While this approach has been called a ‘world first’, it essentially re-examines a century old way of thinking with respect to meta-NPD[8]. What has become evident is that product development and design has an important role in delivering sustainability. The analysis of supply chain data and meta-NPD approaches have now become a reality with supply chain analytics, such as Blockchain, providing the necessary data acquisition platforms[9]. We choose foods based on what we like, what we can access and what we can afford. But continued surveillance and interest in sustainable production will mean that increasingly we can buy products we know has an improved supply chain. As an example, the data associated with the time a product remains in a supply chain and how it is moved is critical to improving NPD because this goes to the heart of quality provision.

New digital tools to allow scaling are in place, a meta-NPD approach is required to take account of all the issues affecting product lifecycle and acceptability to consumers. Understanding how food is prepared and consumed can help answer many questions as to why sustainable targets are often not reached.

References and article available online at fstjournal.org/features/33-1/new-product-development

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In the last thirty years, the prevalence of overweight and obesity across Europe has increased dramatically, particularly among children. The full consequences of this epidemic have yet to unfold, but include an expected increase in cardiovascular disease, hypertension, type 2 diabetes and diverse mental health conditions. These have huge social and economic costs they affect people in the midst of their working lives. Stress, anxiety and depression, together with social stigma and bias in the workplace add to the pressures on families and employment and can enhance the vicious cycle of weight gain through ‘comfort eating’.

Nudge-IT was a multidisciplinary, multinational project funded by the European Union to address the need for a better understanding of the determinants of food choice\[1\]. The project engaged experts in the neurobiology of motivational behaviour, the neuroscience of reward pathways, the neuroendocrinology of homeostatic regulation of appetite, experimental psychology, functional brain imaging, behavioural economics (the scientific study of decision making) and computational neurobiology.

Policy recommendations
To produce policy recommendations on healthy eating that are likely to be effective, we must be able to make valid, non-trivial predictions about the likely consequences of any proposed interventions. In particular we need: confidence in the scientific evidence base, an adequate understanding of the health benefits that are likely to accrue from behavioural change, an understanding of the barriers to change – the reasons why interventions may fail to be effective, and an appreciation of the possible unintended consequences of change.

These are not trivial considerations – if an intervention is successful in getting people to eat less of some foods that we have reason to believe are ‘unhealthy’ when eaten in excess, what will they eat instead and what other consequences for their behaviour might we expect to follow?

For this, we need a better understanding of the determinants of food choice\[2\]. These obviously include dietary components (taste, texture and palatability), but also cultural and social pressures, cognitive factors (perceived stress, anxiety and depression) and familial, genetic and epigenetic influences. Our choices of what particular foods to eat, how much to eat and who are influenced by how foods are marketed and labelled and by economic factors. They reflect both habits and impulses, moderated, albeit imperfectly, by our often incomplete understanding of what constitutes ‘healthy eating’. But they are also influenced by our individual physiological needs – needs which we are not necessarily consciously aware of but which nevertheless affect our behaviour.

Clearly there is a need for a strong evidence base to inform public policy on the issue of healthy eating. However, there is a ‘disconnect’ between our mechanistic understanding and our ‘softer’ knowledge of consumer behaviour, which can make inferences about food choices incomplete and unsafe. For a robust evidence-based policy, it is essential that these inferences are properly validated.

In general, to inform public health policy, scientific evidence needs to include three very different types of information. There is a need for strong evidence of association between, for example, a particular behaviour and a health outcome. But evidence of association does not in itself demonstrate any causal link between the behaviour and the health outcome. So
there also needs to be evidence from interventions to show that changing a behaviour will produce the intended outcome. But if the hope for outcomes (on health risks) are very long term and only to be expected on a population level, it may be difficult to demonstrate a link. Evidence from intervention studies is often weak; they are typically studied for a limited subset of the population under particular conditions and over a limited time period. Accordingly there is also a need for evidence of mechanism: a detailed understanding of the pathways and mechanisms by which a particular behaviour can result in a particular health outcome.

Such mechanistic understanding can give insights, for instance, into the particular groups in society that are likely to benefit from behavioural change, the kinds of intervention that are most likely to be effective, other ‘unintended’ consequences of behavioural change and the likely barriers to change.

These engage a very wide range of questions, including, for instance, how the brain recognises and responds to different food constituents, how our brains decide how much energy and other nutrients we will need for the day ahead and how long-term effects of nutrition affect our behaviour as adults.

**Nudge-IT**

The Nudge-IT project was on tools that will lead to knowledge that translates into policy, and understanding how to make that translation effective. In order to develop new tools to help understand:

a) the importance of early life sensing of determining food choice,

b) habitual eating behaviour,

c) impulsive choice behaviour,

d) the importance of the environmental context in decision-making processes.

The Nudge-IT consortium used a very wide range of approaches to study food choice behaviour and used live human and animal models. These included investigating the effects of hormonal signals, particular brain pathways (brain imaging), how dietary interventions in children affect their food preferences, and how different food compositions affect signalling from the gut to the brain and influence hunger and satiety.

We now focus on one example of how mechanistic studies in animals can give a deep insight into food choice and raise important questions.

**Physiology of eating**

Although it might seem obvious that changes in body weight reflect choices about what food we eat, how much we eat and how much we exercise, the long-term balance between energy intake and energy output is mainly determined by unconscious physiological systems.

Two hormones are extremely important in this: leptin, which is produced by adipocytes (the cells that store fat), and ghrelin, which is secreted from the empty stomach. Both of these hormones signal in the brain, so do many other hormones secreted from the gut and fat stores affect eating behaviour. We also have a growing understanding of exactly where and how they act in the brain and we are beginning to understand the mechanisms by which different food constituents affect hunger and satiety. These physiological pathways have been well conserved throughout mammalian evolution, so knowledge gained from animal models has proved generally to translate well into understanding of human physiology and behaviour.

For example, human brain imaging studies using positron emission tomography and functional magnetic resonance imaging show that these metabolic pathways function in a similar way in humans and rodents. The brain’s response to a palatable food differs from that to bland foods and responses to high-energy and fat-rich foods differ from those who do not. Importantly, cravings for palatable foods activate similar brain regions and involve the same chemical messengers in humans as in rats.

**Response to gavage with palatable food.** Oxytocin cells are activated as soon as food reaches the stomach.

**Rats compensate for a daily sweet treat**

Rats reduce their daily voluntary food intake by 20 calories if given a 20 calorie sweet treat each day.

**Sweet food is rewarding even when we are fully sated.**

Although it might seem obvious that changes in body weight reflect choices about what food we eat, how much we eat and how much we exercise, the long-term balance between energy intake and energy output is mainly determined by unconscious physiological systems.

In children, these differences in food preferences and the different food compositions affect signalling from the gut to the brain and influence hunger and satiety.

**Energy homeostasis** involves much more than regulation of appetite – many other hormones also contribute to varying extents in different people and in different species. In some, excess energy intake is compensated by increased energy expenditure – either in activity levels or in thermogenesis (heat production). But if this homeostatic mechanism is so effective, why do people ever become obese?

This is an important question. When we eat, we are rewarding our brain with the food we eat, and the behaviour of eating itself is rewarding. This is not by any means a new concept; the idea that food is a reward was first suggested over a century ago. ([1])

**Figure 1** Gavage of a high-sugar (SCM) into the stomach of rats increases the electrical activity of brain oxytocin neurones (expressed as firing rate per second). These neurones seem to receive signals from the gut on the nutritional composition of foods in the stomach. Understanding these neurones’ networks and signalling pathways will help us understand better how the brain controls food choice.

**Figure 2** Rats given regular access to a sweet ‘treat’ (a small amount of palatable condensed milk) decrease their voluntary food intake compared to rats that receive no SCM. Rats compensate exactly for the energy content of the treat. Rats in this study did not eat their total energy intake and did not put on any more weight than the controls. This data highlights the complex interaction between eating and energy homeostasis and the influence of physical context on the brain.

**References and article features**

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The Nudge-IT project ended in December 2018 and the final report is in preparation. The many papers produced from this project are available on the project’s website along with some of the key tools developed. The final stages of the work are still in the process of completion and will be added to the website as they are published. The project also involved a number of workshops and meetings to disseminate the findings to other scientists, related professionals and policy makers, and included many activities to raise public awareness and understanding of the issues and of the conclusions made by the project.
Nurturing natural capital

Global agricultural systems are fundamentally dependent on the health of the ecosystems that provide these ‘services’, and can consequently affect their ability to provide the natural ‘inputs’ (ecosystem services) that underpin productive and profitable agricultural systems. The Food and Agriculture Organization of the United Nations (FAO) estimates that, by 2050, the world’s population will reach 9.1bn (medium variant), 34% higher than today's global population.

According to the UN Convention to Combat Desertification’s (UNCCD) Global Land Outlook report, one third of Earth’s soil has already been acutely degraded due to agriculture; the world may have as little as sixty harvests remaining (on average).

In an ‘agriculture as usual’ scenario, a significant increase in production, in the absence of a strong conceptual understanding and strategic decision-making processes, could lead to potential devastating consequences for ecosystems and climate, with correspondingly significant risks for agricultural production systems and societies around the world.

Simply put, natural capital is another term for the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits (via ecosystem services) to people. If managed effectively, a renewable natural capital stock (for instance pollinators and pollinator habitat) can continue to deliver benefits or ‘dividends’ (in the form of the provision of pollination services) in perpetuity.

If the stock itself is eroded past a sustainable level (for instance, if pollinator habitat is destroyed to make room for marketable crops), then the provision of ecosystem services will be reduced or disappear completely, with subsequent impacts on those dependent on pollination services and other services provided by the stock.

Framing relevant parts of the natural world as stocks of natural capital can help organisations to understand the complex, dynamic and sometimes opaque ways in which their success is dependent on natural systems, organisms and phenomena, how their activities across these systems are impacting on their abilities to be successful, and what information and actions are necessary to help preserve these resources.

Once dependence in certain ecosystems and their services is understood, the rationale to protect and conserve them can be fed into traditional risk management and strategic decision-making processes. Based on this understanding, subsequent actions may focus on the identification of areas for targeted investment or conservation, the development of more efficient, holistic and resilient agricultural policies and practices, or the identification of opportunities for innovative holistic solutions.

A natural capital approach can also be applied to identify cost-effective nature-based solutions, which provide cost-free co-benefits for society and the natural world alongside the creation of business value.

For instance, the restoration of pollinator habitat may provide a net saving when compared with the cost of trucking expensive artificial beehives onto farmland, but provide equal levels of service provision, while additionally creating recreational space for local communities and providing further ecosystem services.

While those engaged in the agricultural sector possess a strong conceptual understanding of their direct impacts and dependencies on natural capital, this understanding alone is often not enough to enable them to successfully address issues and make informed decisions in the absence of a standardised framework to guide them, and an enabling economic and policy environment.

The Natural Capital Coalition (the Coalition) was created in order to address this gap in knowledge and implementation. The Coalition is an international collaboration, made up of almost 300 organisations, that unites the global natural capital community. Coalition organisations have a common vision of a world that conserves and enhances natural capital.

In July 2016, the Natural Capital Coalition released the Natural Capital Protocol (the Protocol), an internationally standardised decision-making framework that enables organisations to identify, measure and value their direct and indirect impacts and dependencies on natural capital in order to inform decision-making.

The Protocol was developed by a core team of 38 organisations, while over 450 organisations provided input over the course of the two-year project. Organisations and professionals from across six continents offered over 4,200 comments during consultation. The Protocol was piloted by 50 leading businesses including Nestlé, the Coca-Cola Company, Olam, Nespresso, Dow, Shell, Kering, Hugo Boss, Yorkshire Water and Interface. Several Sector Guides and supplements have been developed to accompany the Protocol, including the Food and Beverage Sector Guide, which provides additional guidance and sector-specific insights to those carrying out a natural capital assessment. It identifies natural capital impacts and dependencies most relevant to businesses operating in the sector and offers practical guidance and examples to demonstrate Protocol applications.

Simply put, natural capital is another term for the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits (via ecosystem services) to people.

Just as those in the agriculture sector must understand their impacts and dependencies on natural capital, it is becoming increasingly clear that other forms of capital need to be considered in order to understand impacts and dependencies across the entire value chain. The Natural Capital Coalition is working with the newly formed Social & Human Capital Coalition to ensure that economic, environmental and social issues are addressed within a single interconnected system.

This move towards further integration is also the rationale for the TEEBAgriFood Evaluation Framework set out below.

A holistic, capitals-based and value chain approach to food and agriculture

The idea that nature is fundamental to human well-being is incontestable. Yet much of the value that we attribute to...
Ecosystem services or natural capital is not accurately reflected or accounted for in markets. Narrow metrics like GDP growth, for example, ignore the contribution that nature makes towards achieving that growth, as well as its impacts on environmental and human welfare. As a result, decision-makers are left to rely on partial, often misleading, information to make key business and policy choices that continue to exacerbate these problems. This ‘economic invisibility of nature’ is precisely what sparked ‘The Economics of Ecosystems and Biodiversity’ (TEEB) initiative in response to the need to make key business and policy choices that continue to exacerbate these problems. This ‘economic invisibility of nature’ is precisely what sparked ‘The Economics of Ecosystems and Biodiversity’ (TEEB) initiative in response to the need to make key business and policy choices that continue to exacerbate these problems. This ‘economic invisibility of nature’ is precisely what sparked ‘The Economics of Ecosystems and Biodiversity’ (TEEB) initiative in response to the need to make key business and policy choices that continue to exacerbate these problems.

TEEB brought global attention to this problem through a series of reports in 2010 targeting key end-users in academic, business and policy circles. In an effort to dig deeper, TEEB later focused on the agriculture and food sector in order to illuminate the integral and invisible role that nature plays on our farms, and the far-reaching impacts of agriculture on our natural environment. Evidence was abundant for the ‘usual suspects’ in terms of drivers (such as greenhouse gas emissions, deforestation, pollution, soil degradation, and eutrophication) leading to negative environmental outcomes (such as biodiversity loss and the decline of pollinators). Yet research was quickly unravelling a complex web of hidden costs of agri-food systems going unchecked: food insecurity, malnutrition and obesity; contamination and pathogens; occupational hazards; food loss and wastage; child labour; gender inequality; rural poverty; land conflicts, farmer suicides, animal mistreatment; and the many other impacts and dependencies within the value chain of corn. This is a complex undertaking, as illustrated by Figure 1, which gives a general impression of how truly important agriculture and food systems (represented by the value chain) are for human welfare, and how deeply intertwined their linkages (both visible and invisible) are with our economic systems (represented by the four capitals).

Figure 1 Links between agriculture and food value chains and four capital bases

**TEEBAgriFood and its growing community of practice is pilot-testing various applications of this approach and Framework in order to build up a solid foundation of evidence as proof of concept. Over time, it is anticipated that the research findings and the growing community of practice behind them, will contribute to a powerful case for change of today’s prevailing yet outdated agricultural and economic paradigm. Disseminating such a counter-narrative is essential in order to drive much needed political support for more effective agenda-setting and policy action.**

From theory to practice: applying the Framework to maize value chains

The TEEBAgriFood Evaluation Framework set out above seeks to support the evaluation of all positive and negative impacts and dependencies of eco-agri-food systems across the value chain. This is neither a simple nor straightforward task, as it must bring together the natural and social scientists, environmental and agricultural economists, and experts in health, poverty, land conflicts, farmer welfare, consumer health, worker welfare, animal migration – not to mention the flip side of the coin, where achieving positive strides in system resilience, worker welfare, consumer health, or ecological sustainability was being largely undermined. Indeed, our focus on single metrics for agricultural performance, such as yields or profits per hectare, were as reducive and narrow-minded as GDP overlooking vast swathes of negative and positive interactions. By failing to recognise these and demonstrate their values in economic terms, businesses and policymakers would also fail to capture them. The end result is a significantly and dangerously distorted perception of the economic environment in which farmers, agribusinesses, consumers and decision-makers operate.

Figure 2 Elements of the TEEBAgriFood Evaluation Framework

**COMPONENT LINKS**

**IMPACTS**

Environmental impacts
Economic impacts
Social impacts
Health impacts
**CONTRIBUTIONS TO HUMAN WELL-BEING**

Depression in mental health and quality of life
Improved mental health and quality of life
**PRODUCED CAPITAL**

Natural capital
Human capital
Social capital
Financial capital
**AGROFOOD VALUE CHAIN**

Manufacturing and processing
Retailing
Consumer
**OUTCOMES**

Changes in the capital base
**HUMAN CAPITAL**

Education and skills
Income and employment
Health
**ECOSYSTEM SERVICES**

Providing and regulating services
Supporting and cultural services
Cycling pollution, food systems
**RESIDUALS**

Agricultural and food output
Purchased inputs
**PRODUCTIVE CAPITAL**

Land, water, soil, vegetation biomass, etc.
Buildings, machinery and equipment, human capital, natural capital
**INPUT FLOWS**

Agricultural and food products, income effects, capital and social capital, natural capital
**STOCKS**

Water, soil, vegetation biomass, etc.
Health and human capital, natural capital

**ENVIRONMENTAL IMPACTS**

Deforestation, biodiversity loss, pollution, soil degradation, pollinators, etc.

**HUMAN CAPITAL IMPACTS**

Depression in mental health, stress, suicide, etc.

**SOCIAL IMPACTS**

Increased access to food and health opportunities
Land displacement

**ECONOMIC IMPACTS**

Negative environmental impacts
Economic impacts

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The end result is a significantly and dangerously distorted perception of the economic environment in which farmers, agribusinesses, consumers and decision-makers operate. Change in the form of a more holistic approach is needed – one where ecological, social and human values are taken into account and the true cost of agriculture and food is reflected across the entire value chain, from the inputs to production to the impacts of consumption, including waste at each stage. This is a complex undertaking, as illustrated by Figure 1, which gives a general impression of how truly important agriculture and food systems (represented by the value chain) are for human welfare, and how deeply intertwined their linkages (both visible and invisible) are with our economic systems (represented by the four capitals). TEEB for Agriculture & Food (TEEBAgriFood) responds to this need by calling on a systems thinking approach in designing a new lens through which agriculture and food systems can be viewed. A group of experts have developed an Evaluation Framework (Figure 2) that seeks to provide a clear and common starting point for assessments of agriculture and food systems, practices, products and policy scenarios against a comprehensive range of impacts and dependencies along value chains.

Utilising a comprehensive and universal Framework provides a common basis to compare assessments, a tool for decision-makers to understand what information is missing, and a means to identify areas of further research. By including all categories of material interactions in a given food system, the Framework can offer entry points to many people – for example, researchers focusing on social impacts of food systems can use social capital related outcomes as a starting point, and then make linkages to the other three capitals to buttress their work. In essence, no matter what the starting point or purpose, the Framework can allow researchers to contextualise their assessments within a broader and more holistic set of interactions, bringing transparency to their assessments, but also highlighting synergistic opportunities to link with others.

ENvironment, with support from the European Union and Germany, is also taking forward a number of country study approaches in China, Colombia, India, Indonesia, Kenya, Malaysia, Mexico, Tanzania and Thailand. The first study aimed to understand the value links between produced, social, human and natural capital in corn production systems in the Mississippi basin in the US. It evaluated the true costs and benefits associated with conventional and organic production systems by examining all impacts and dependencies within the value chain of corn. The study evaluated the four capitals in corn production systems in Minnesota. Produced capital included production inputs and outputs from a corn farm. There are about 24,000 conventional corn farms that generate a corn crop value of more than $4.5bn for Minnesota. Minnesota also has over 500 certified organic farms. Social
capital includes farmer networks, market linkages, norms and trust amongst the rural community and the private and public sectors. These enable farmers to act together more effectively to pursue shared objectives. In Minnesota, corn growers have an extensive network from individuals to communities and from farms to national level. This network extends in both private and public sectors of the corn-based economy in the US. Human capital includes farming knowledge, skills of farmers and farm workers, and individual attributes that facilitate the creation of social and economic well-being of the rural community. There is a growing divide between rural and urban population in Minnesota due to urban migration trends since 1900. The average age of farmers is more than 55. A majority of the rural population has a high school qualification, as opposed to those in urban areas, where qualifications are higher. Rural residents have a high rate of obesity and heart diseases compared to those in urban areas. As a component of human capital, health of residents around corn farms in Minnesota was investigated. There are significant non-financial health costs associated with GM corn production in Minnesota. Impacts on natural capital associated with corn production were evaluated in terms of climate change and water, air, and soil quality. There is a high total environmental cost associated with corn production in Minnesota.

This information can be used to develop policy and practice to improve corn production systems and minimise impacts on environment and human health in the Mississippi basin. The linkages between the four capitals in corn production systems are being further investigated to analyse farm, environmental and health policies and other capital systems’ linkages related to corn production.

Maize systems in Malawi

Maize is widely considered to be central to food security in Malawi, however, “maize led development” has so far produced disappointing outcomes. Despite being one of the few countries to meet the goals of the Comprehensive Africa Agriculture Development Programme (CAADP), and notable increases in average national maize yields, human development indicators have scarcely budged and, in some cases, are deteriorating. High volatility characterises maize markets; diets are poorly diversified, malnutrition among children remains high and poverty levels have increased in recent years. In addition, environmental resource stocks, such as agrobiodiversity and soil fertility, which are particularly critical to smallholder farmers who are not able to easily access purchased inputs, are deteriorating due to the continuous cropping of hybrid maize on small tracts of land.

Maize is a notoriously finicky and demanding plant that can only produce well under a narrow range of conditions. This suggests that the focus on maize is disproportionate to the benefits it provides, especially in light of the devastating and widespread socio-economic impacts of climate change. This study used the TEEBAgriFood Framework to explore the costs of continuing with a maize-centric agri-food system, as well as the factors that keep this system in place despite calls for agricultural diversification.

Chief among those factors is the Farm Input Subsidy Programme (FISP). Both maligned and celebrated, FISP has consumed the majority of Malawi’s agricultural budget since 2004. Most often blamed for the renewal of FISP each year is the farmers’ cultural attachment to maize in combination with a system of political patronage. In addition, this study looked beyond the borders of Malawi to assess how a wider set of historical and contemporary interests perpetuate maize-centricism. The study illustrated how a broader analysis can identify opportunities for strengthening the agri-food sector in Malawi. The overall effect of FISP has been to increase maize monocropping, and to induce the adaptive capacity of the agri-food system. Most studies on food systems in Malawi are disciplinary in nature and do not necessarily shed light on the relationships between a maize-centric agricultural system and outcomes related to human or environmental wellbeing. In addition, few studies have attempted to unpick the various dependencies in systems and how they entrench practices and stagnate system evolution.

The TEEBAgriFoodFramework provides an alternative that can improve understanding of food-society-environment relationships and the outcomes they produce. Recommendations include refocusing agri-food systems development to address the infrastructural and institutional capacity of Malawi’s food economy and investment in so-called ‘soil’ or indigenous crops that are more suited to local environments and can withstand a greater range of agroecological conditions.

The costs and benefits identified by application of the TEEBAgriFood Framework to the two different corn production systems will be used to develop recommendations and guidance for end users, i.e. farmers and policy makers.

Conclusions

A more holistic, systems approach is required to ensure that ecological, social and human values are taken into account in assessing the true costs of agriculture and food across the entire value chain. The Natural Capital Protocol has been developed to enable organisations to identify, measure and value their direct and indirect impacts and dependencies on natural capital.

This work is complemented by the TEEB for Agriculture & Food Evaluation Framework, which provides a common basis for assessing produced, social, human and natural capitals in order to compare food systems, practices, products and policy scenarios. Such frameworks and tools can allow more informed decision-making and help to manage our renewable stock of natural capital more effectively. Pilot studies testing the Framework are being developed, often in collaboration with others, a wide range of activities and events.

References and article sources online: www.ifst.org/features/33-1/natural-capital

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The case for sustainable palm oil

Palm oil cultivation

Originating in West Africa, the oil palm crop is commercially cultivated today on a large-scale across Asia and increasingly in Latin America and Africa — growing most successfully in tropical regions close to the equator.

The global popularity of palm oil and its versatility has helped drive a rapid expansion of oil palm plantations, predominantly in Malaysia and Indonesia. It is extracted from the flesh of the fruit of the oil palm and also when the kernel of the fruit is crushed. Palm (kernel) oil is a favourable ingredient for food production as it maintains its properties at high temperatures, has a smooth and creamy texture and possesses no distinct smell. Palm oil also has a natural preservative effect, which extends the shelf life of food products. The oil is also widely used by the home and personal care sectors. Approximately 2% of the world’s palm oil and palm kernel oil is used in cosmetics, while 3% is used in home care.

As an ingredient in many of the products on supermarket shelves, from margarine and chocolate to ice cream, soaps, cosmetics, and even as a biofuel for cars and power plants, it is easy to see why there has been such large-scale market demand for the oil. Palm oil is the most consumed vegetable oil globally and also the highest-yielding vegetable oil crop, needing less than half the land required by other crops to produce the same amount of oil. This makes it very efficient and the least expensive vegetable oil in the world.

Yet in some regions, oil palm cultivation has caused and continues to cause deforestation. Land, which was once predominantly covered by primary forest (forest untouched by man) or which housed protected species and a high biodiversity, has been cleared in order to be converted into palm oil plantations. Likewise, some palm oil plantations have been developed without consulting local communities. Some have even been responsible for forcibly displacing people from their land. Violations of workers’ rights to fair payment and safe working conditions, and other malpractices have also occurred. While the oil palm crop in itself is not unsustainable, production practices have exacerbated or created the environmental and social concerns that have become apparent in the last few decades.

Roundtable on Sustainable Palm Oil

In 2004, in an effort to combat these challenges, the Roundtable on Sustainable Palm Oil (RSPO) was established to promote the sustainable production of palm oil. RSPO certified oil palm growers are audited by an independent, accredited certification body that verifies that production processes adhere to the RSPO Principles and Criteria (P&C), a robust set of stringent social and environmental guidelines that they must follow. As a non-profit, international membership organisation, RSPO unites approximately 4,000 stakeholders from 62 countries representing all sectors of the palm oil industry — producers, processors, traders, consumer goods manufacturers, retailers, banks, investors, environmental and social non-governmental organisations and civil society organisations. By bringing stakeholders together to seek solutions to the challenges of the palm oil sector, RSPO has created a platform to transform how palm oil is produced, traded and sold. Membership has more than doubled in the last five years and today, approximately 19% of all palm oil produced globally is certified to RSPO standards. The result of this gradual transition is an increasing amount of palm oil in our products that has been produced and sourced in a sustainable manner. Despite widely-reported malpractices in the palm oil industry, a growing number of players have committed to adopting more sustainable practices and have joined RSPO to help achieve our common mission to make sustainable palm oil the norm.

Some of the negative environmental impacts of palm oil cultivation, such as deforestation and social issues, are well-documented and a cause of concern for many consumers, particularly in the UK. For these consumers, it is imperative that action is taken to ensure that the industry operates responsibly, so that all palm oil is sourced sustainably. When grown sustainably, and to RSPO standards, oil palm plantations and the environment can co-exist – ensuring that forests with high conservation value (HCV), including the habitats of wildlife, are not harmed.

Replacing palm oil

Avoiding or boycotting palm oil is not a sustainable solution and could in fact make matters much worse. Although using other vegetable oils might seem like a practical solution, it would actually create similar — if not even larger — environmental and social problems in different production areas. There is a misconception that sustainability concerns can be addressed when companies simply stop using palm oil in their products. This would have several grave repercussions on land, society and industry.

Replacing palm oil with other types of vegetable oil (such as sunflower, soybean or rapeseed...
In 2018, RSPO also launched economic viability of businesses. Participation, and ensuring livelihoods, valuing community conservation, reducing poverty, innovative, transparent and take place, the global market to request and buy products that manufacturers and consumers shift to exporting unsustainable countries to use sustainable oils would not give the products industry. Moreover, replacing palm oil with other types of oil is not always feasible due to palm oil’s unique properties as a food ingredient. Using other oils would not give the products the same texture and taste that palm oil offers. If Europe moves away from palm oil, there will be less incentive for producing countries to use sustainable practices and instead focus will shift to exporting unsustainable palm oil to less demanding markets, such as India and China, or to local consumption. Therefore, the best solution for tackling sustainability is for manufacturers and consumers to request and buy products that contain certified sustainable palm oil.

For real transformation to take place, the global market needs to become more inclusive, as well as more competitive, innovative, transparent and resilient. RSPO sees a future where it is standard practice to realise benefits for all palm oil stakeholders by improving conservation, reducing poverty, supporting sustainable livelihoods, valuing community participation, and ensuring fair labour practices and the economic viability of businesses.

Sustainability College

In 2018, RSPO also launched its Sustainability College – an engaging and easy-to-use platform offering stakeholders fun, educational content about sustainable palm oil. The Sustainability College includes video content, an interactive leader board, and quizzes on topics like Free Prior and Informed Consent (FPIC), Certification, Remediation and Compensation Procedures (R&C) and more. The platform aims to educate and inform our seven stakeholder groups about sustainable palm oil related topics in a unique and interactive way. It launched with six courses: FPIC, R&C, The Role of Certification, Best Management Practices (BMPs) for Existing Oil Palm Cultivation on Peat, New Planting Procedures (NPP), and Greenhouse Gas (GHG) Emissions – the range of courses on key topics continues to grow.

Palm oil workers
Plant factories of the future

Introduction
The global population is increasing exponentially and the demand for food is rising at an unprecedented rate. Vertical farming is a crop production system for the future, which may offer the solution to providing food for the expanding population predicted to increase by a further 3bn by 2050.

Vertical farming is a technique for growing plants on a series of levels in a vertical space, where all parameters essential for plant growth, such as light, temperature, water, nutrients and carbon dioxide, are provided at a continuous, optimum level. In theory, this combination of inputs provides the best environment for crop growth, yet it also can create issues with labour requirements and the electrical power consumption, as well as numerous other aspects.

Using controlled environments, crops can be cultivated that may otherwise be unsuited to the UK climate, reducing reliance on overseas supply chains. Another factor in the provision of high quality, fresh produce is the control of microbiological contamination throughout the production process, particularly where the final product is presented in a ready-to-eat format.

Designing an intensive plant production system
The Jones Food Company initiated a project to design, build and operate a commercial, high-care, intensive plant production unit. The facility is now up and running, having produced its first harvest of culinary herbs and leafy greens during the Autumn of 2018. The construction method needed to be both modular and scalable to enable subsequent units to be efficiently assembled in any area where food production is required, including urban spaces.

The production system design incorporates the latest knowledge and research on hydroponics, LED lighting and environmental control systems. Initial water filtration, precision irrigation and recirculation of drainwater (irrigation solution not used by the plants) are key factors in the overall water-use strategy. Additional filtration and the use of ultra-violet light treatments ensure that the water quality is maintained throughout the unit (Figure 1).

The building itself was originally constructed as a cold storage facility (Figure 2) and is very suitable as a controlled, multi-level, growing environment. It is well insulated and twelve metres in height. This has allowed the construction of five main growing racks, each containing seventeen crop production units, measuring ten metres wide and twelve metres in height. This recycled metalwork was then incorporated into the new growing structure, which supports the growing trays and crop produce.

The unit is divided into separate zones for seed sowing, germination, crop growing, harvesting, tray cleaning and despatch. All main areas have independent environmental controls and the unit is sealed to prevent pest ingress from the outside. As a result, the pest and disease risk is lowered and, therefore, there is no need to use pesticides in the unit.

A separate consideration was to automate the crop production and harvesting processes as far as possible, to further reduce the risk of contamination. The use of automation at every stage throughout the production and harvesting processes reduces the requirement for handling of the food products, resulting in a lower microbiological contamination risk. Another positive benefit of this system is less waste product.

The unit layout was designed to allow the operation of an autonomous forklift vehicle from the seedling area into a separate germination chamber and, subsequently, to the growing room and harvesting zone. A purpose-designed quality management system has also been compiled to match and evolve with specific customer requirements.

Paul Challinor of Jones Food Company describes a new high-care, multi-layer, hydroponic plant production facility in the UK.

Using controlled environments, crops can be cultivated that may otherwise be unsuited to the UK climate, reducing reliance on overseas supply chains.
LED lighting and cropping

The LED lighting profile uses Current by GE Blue Light lights (Figure 3), which were firstly tested on a small growing rig. After extensive trials involving many plant types, a balanced light spectrum was selected to allow efficient plant growth and optimum product quality. Important considerations for final selection of the lights included the LED efficiency (conversion of energy to light), spectrum, longevity of the luminaires and ease of installation.

Light is one of the most important environmental factors influencing herb quality, phytonutrient content and growth and development. The recent adoption of light-emitting diodes provides opportunities for targeted regulation of growth and phytohormone accumulation by herbs to optimise productivity and quality under controlled environments.[9]

This facility is currently growing culinary herbs and leafy greens (Figure 4), but the unit is capable of growing most plant types and may be adapted to accommodate larger plants by adjusting the number of growing levels per rack in order to create additional height per growing tray (Figure 5). Studies growing lettuce under LEDs have demonstrated that growth and nutritional values can be enhanced in indoor plant production facilities.[10]

Further plant growth and variety testing are planned; a range of crop plants may be cultured under the GE LED lights by manipulating the photoperiod.

Treatment of growing materials entering the high-care unit

All materials destined to enter the growing and harvesting areas are treated with UV-C light. Both the growing substrate and the cropping trays enter the high-care areas via an enclosed tunnel, which allows 360° exposure to the UV-C light. In addition, all seed is tested before use to monitor microbiological levels and is treated with UV-C in a separate machine, before delivery into the high-care unit. The seed treatment mechanism involves the use of a vibration belt, which causes the seed to tumescent, allowing all surfaces of the seed coat to be exposed to the UV-C light.

Potable water is filtered and UV-C treated via a two-stage process, prior to storage in a separate water management building. This provides a clean water supply for all uses inside the facility. Other storage tanks contain concentrated liquid nutrients and diluted nutrient solution is injected into a series of day stock tanks, ready for crop irrigation.

Clean liquid feed, at a known pH level and electrical conductivity (EC), is irrigated into the growing trays, which hold the growing substrate and support the growth of the crops. Drainwater is captured from each growing rack and returned to this water management area. From the drainwater tank, the liquid feed is transferred back to a clean storage tank, via a separate UV-C treatment unit. This allows extraction of fresh liquid feed and treated drainwater to be irrigated back to the growing crop on a continuous basis.

In terms of labour, all crop operatives complete a sequence of hand washing, use of protective cleanroom suits, hoods and boots, final hand washing and hand sanitising, prior to entering the high-care area. The final step before entering is via a pharmaceutical air-shower unit, to remove any extraneous dust particles (Figure 5).

Intensive hydroponic system

Hydroponics is the culture of plant crops in soilless water-based systems, where nutrients come only from formulated fertilisers.[11] The Jones Food Company irrigation system operates on an drip and flow principle, where liquid feed is allowed to drain away from the plant trays after flood irrigation. This permits oxygen to reach the root zone in order to maintain root health. It also allows a much reduced usage of water and fertiliser (as all of the drainwater is captured and recirculated back to the crops), compared to traditional farming conditioning system (Figure 6). Fan units fitted along every rack also help to increase airflow along the plant production rows.

Microbiological testing

The unit is sampled on a weekly basis to monitor the microbiological levels inside, as well as the effectiveness of the various cleaning regimes in place for operatives, machinery and the fabric of the internal environment. An external pest contractor is used to check the outside of the building and flying insect monitoring apparatus is also used to validate the food safety controls inside the high-care unit.

Phytonutrients

Research has indicated that for most herb species, red light supplemented with blue light significantly increases plant yield.[12] Basil cultivars grown under LEDs, for example, showed increased total phenolic content compared with plants grown under conventional fluorescent lighting.[13] The antioxidant capacity of assessed basil cultivars was improved when doses of potassium fertiliser were increased in the nutrient solution.[14]

A collaborative study on the phytochemical content of plants raised under LED lights was initiated at Lancaster University in October, 2017. The study is investigating optimisation of phytonutrient and vitamin content of herbs and salad leaves grown in an intensive, multi-level hydroponics system.

The results from the research should be directly applicable to the new crop production facility.
Pesticides in agriculture

Introduction
The first part of this article explored the history and use of agricultural pesticides and focused on two important classes: herbicides and insecticides. Attention is given here to other pesticides of importance to farmers, as well as issues associated with their use—principally environmental sustainability and human health.

In the production of agricultural food materials, herbicides are ubiquitous in the management and control of undesirable plant species that compete with crops and insecticides are important to both crop and farmed animal protection. Other biotic threats to both crop and farmed animal health are various fungal species, which can be problematic in crop production, nematodes, which threaten plant and animal, and common rodents.

Farmers seek to gain advantage over the variety of pests that threaten crops and animals. Failure to do so can result in product losses and reductions in yield, quality, and profit as well as, in certain instances, food safety hazards. Although farmers constantly seek to control the environment in which they produce agricultural foods through the management of pests, they must also remain cognisant of the possible negative impacts that pest control measures may have on local ecology and biodiversity, as well as the capacity to sustain food production resources for future use.

As the agricultural pesticide industry developed through the 20th century and became an integral part of the mid-century Green Revolution, modern farmers, particularly in Europe and North America, embraced the technology and profited from huge increases in yield. However, with the benefit of hindsight, we are now beginning to understand that while synthetic pesticides offer immediate benefits for farmers and consumers, they also bring longer-term concerns about negative effects on ecosystems and wild biodiversity.

The second part of this article (part one was published in the December issue of FS&T) Ralph Early describes the control of fungal, nematode and rodent pests and discusses the future of synthetic pesticides in agriculture.

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states that PCNs are the most important pest pests in Britain capable of causing substantial yield losses; with two species, Globodera rostochiensis and Globodera pallida, being of particular concern. G. pallida is now more widespread due to a prolonged batching period and selection pressure provided by the cultivation of potato varieties resistant to G. rostochiensis.

The carobam insecticide, aldicarb (C7H14N2O2S), which functions as a cholinesterase inhibitor, was widely used to control nematodes. However, it is extremely toxic and environmentally persistent, having been implicated in the collapse of ecosytems and the irreversible poisoning of farmland. It is also considered to be carcinogenic to humans and has been banned in some countries, although it is permitted in others, such as the USA, where commercial formulations are used in the production of cotton, beans, peanuts, soybeans, sugar beets and sweet potatoes. Biological methods of nematode control in crop production are now of increasing interest as an alternative to synthetic nematocides. Matthews[9] describes use of the bacterium, Paenibacillus methanolicus, a cyst nematode parasite, as a means of such control. He also reports the use of biopesticides derived from fungi, such as Paecilomyces lilacinus, which is one of a number of nematophagous fungi producing toxins able to immobilise nematodes. A variety of parasitic nematode species affect farmed animals, such as cattle, sheep and pigs, for example the large roundworm, Ascaris suum, causes ascariasis. Roundworm treatments include piperazine, but it is now more widespread due to a prolonged batching period and selection pressure provided by the cultivation of potato varieties resistant to G. rostochiensis.

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Interesting new qualification developments and plans of the new Food Skills Sector Council.

With Food Matters Live as a backdrop, IFSF hosted the first of its new Education & Careers Forums in November, chaired by Prof Richard Frazer. The Forum attracted representatives from across the sector for an update on T-levels (see technical qualifications for 16-19 year olds), apprenticeships, food graduate competences and the plans of the new Food Skills Sector Council.

Updating on the introduction of T-levels, Janette Graham, 2 Sisters Food Group Technical Learning and Development Lead, explained that they are intended to change the technical education landscape, putting in place a more consistent framework for industry-focused qualifications. They aim to prepare students for entry into skilled employment and are based on the occupational standards (level 3) being developed by the Institute of Apprenticeships (IoA). The first students are due to commence training from September 2020 with food science students starting from 2021, and qualifying in 2023. The training will be classroom delivered over two years by an FE provider, with a requirement for 20% on the job training.

IoA has formed 16 T-level panels of employers, professional bodies and providers to define the knowledge, skills and behaviours required in each occupation. Food science sits within the health and science route. Once the outline content has been agreed, IoA will find an awarding organisation to translate content into a qualification for Further Education (FE) providers to deliver. There will be one awarding body for each of the 16 routes.

Delivering the 45-day industry placement for students in their second year of study will be one of the greatest challenges to the introduction of T-levels. Andrew Gardner reports on IFSF’s first Education & Careers Forum held at Food Matters Live in November 2018.

Delivering the 45-day industry placement for students in their second year of study will be one of the greatest challenges to the introduction of T-levels.
distribution of the sector (being composed of many SMEs), its image (low skilled, low tech, low pay), skill shortages and low apprenticeship numbers. Brexit (20% EU nationals employed in the UK work in food and drink) and digitisation (£55.8bn potential value to sector by implementing ‘known’ digital technologies) also present new challenges and opportunities.

The workforce group has established three task groups looking at apprenticeships, future workforce planning and upskilling the workforce. The issue of the food and drink sector image is a complex one. One key problem is the number of competing initiatives designed to tackle this: the challenge to government to help industry navigate these initiatives.

Government and the Council are looking at:
- increasing the number of apprenticeships and T-level placements in industry;
- finding mechanisms to offer smaller businesses the opportunity to benefit from the levy;
- ensuring employers are aware of the 20% off-the-job training requirements;
- encouraging collaboration to allow businesses to access STEM-related standards;
- sharing clear messaging around career campaigns across the sector;
- The Council is asking the Government to:
  - run an apprenticeship campaign to change perceptions and raise awareness that apprenticeships can be suitable for upskilling too;
  - find new ways to allow the levy to be spent on employees (especially when involving the devolved nations);
  - put in place a future immigration policy that works for the food chain.

Longer term ambitions could well include making food a recognised career route rather than splitting it across hospitality, manufacturing and science, and making the T-Level a broad curriculum option before specialising in a specific food occupation.

Summarising the contributions, Prof Frazier said that finding solutions to some of the challenges faced by the sector would depend on bringing people together, making bodies like IFST and FDSC even more specialising in a specific food occupation.

Whether or not the Government sticks to its previously announced target of creating three million apprenticeships by 2020, must would agree that apprentice schemes are vital to the future of British industry and creating the next generation of engineers and technicians.

The Proseal Apprentice Training Scheme is central to the continuing success and growth of the company. It helps to foster new talent, developing skilled leaders and innovators, who will help to shape how we heat seal food packaging in the future. Apprentices have been part of Proseal almost since it was first established over 20 years ago. The company has its own state-of-the-art training centre at its headquarters in Addington, Cheshire, which was recently awarded ‘Large Apprenticeship Employer of the Year’ by Macklesfield College. This has allowed us to bridge the gap between classroom learning and practical training and meant we can significantly increase the number of apprentices we take on each year.

Our apprentice scheme is scheduled over a four-year period. During their time with us, apprentices are given the chance to sample every department in the company — including electrical, assembly, manufacturing and motion mechanics — before selecting the area in which they wish to specialise. Typically, by year three, they are all but doing their preferred job.

Throughout this time, our apprentices receive practical, on-the-job training;
- they are mentored by our experienced training staff;
- they work closely with Macklesfield College, where they attend classes and have an assessor who visits regularly to assess their work on site;
- they take part in off-site work at a variety of customer factories and other businesses around the UK.

Their progress is closely monitored, with constant feedback. This includes progress reports detailing their performance in each department and witness assessments in which we analyse their ability to carry out required tasks. In this way we aim to provide our apprentices with all the support they need to assess the career options that are open to them and to help them make the best choices.

Investment in young people will bring long-term rewards to both the trainee and company, as all possible measures are taken to make Proseal a warm and welcoming place for young people. For example, our apprentices wear red shirts for the first two years, meaning everyone is aware that these people have limited experience and exposure to the risks in the business. Also, they will not be expected to perform tasks unsupervised in this period and possibly even beyond.

The success of the scheme is demonstrated by the fact that 98% of our apprentices remain within the company after their training. Indeed, 23 of our current employees came through our apprentice scheme — including 14 who have now risen to become senior decision makers in the business, two of whom are from the original intake 18 years ago.

This year Proseal is in discussions to set up a partnership with another local college. Between January and May every year, we frequently visit schools, colleges and career conventions to raise awareness of the scheme and of careers in engineering. This enables us to invite potential candidates to look around the facility and understand what is expected of a Proseal apprentice.

Our efforts are rewarded when we witness the amazing effect the scheme has on so many apprentices. They turn from shy 16-year-olds into fully-fledged engineers, brim-full of confidence and know-how and ready to do good things in the world of engineering.

The Apprentice Training Scheme is central to achieving Proseal’s growth strategy and helps to ensure that high-quality design and manufacturing can continue to take place in Britain today.
Acroculpia of opportunities

One thing that we often overlook when setting out on a career in food science is the support available to help navigate the opportunities and pitfalls that lie ahead.

**Learned societies and professional bodies**

A source of support for the early stage food scientist or technologist can be found within the learned societies and professional bodies. They not only offer a raft of support services to students, postdocs and early career industry employees. Those wishing to keep up to date with recent developments and meet people from industry and academia can find many opportunities within the IFST (Institute of Food Science and Technology)6, and the SOPHIT (Society of Food Hygiene Technology)7, which are dedicated to the food sector, as well as the SCI (the Society of Chemical Industry)8, the IChemE (Institute of Chemical Engineers)9, the IoP (Institute of Physics)10 and the RSC (Royal Society of Chemistry)11, which all have food related technical Interest Groups.

The IFST has a long history of collaboration with the SCI Food Group and many food scientists are members of both organisations. The IFST runs an annual LaunchPad event at which advice and help is provided to students on career choices. It also provides an online management and training system for continuing professional development (mp/CPD) to help young food scientists keep a record of development activities for career progression and professional registration. In recent years, the SCI has established a number of early careers groups, including most recently the Agri-Food Early Careers Committee, formed in 2016, born out of the Food, Agrisciences, Lipids and Horticulture Technical Interest Groups. It provides a platform for hosting activities aimed at supporting personal and professional development, identifying and nurturing transferable skills and hosting regular symposia, where early career researchers from industry and academia can come together to showcase their research. The SCI has recently launched a new Mentoring Programme, designed to match early career members with an independent mentor who will help them to address specific goals in their careers. Such events and activities provided by IFST, SCI and other institutions are good opportunities to mix with people from the industry, raise your profile, enhance your employability or be an ambassador for your company or university. They are also an excellent means of cross fertilisation between the disciplines, such as food chemistry, engineering, biochemistry, microbiology, formulation and sensory sciences.

**Events and competitions**

The IFST, supported by the SCI Food Group, hosts the annual Young Food Scientist competitions open to both undergraduate and postgraduate students, providing them with a chance to present their research to their peers and a panel of industry experts. The Nusretiye Postgraduate Flavour Symposium brings together researchers in flavour from the leading university departments across the UK and the Republic of Ireland to discuss their research with other early stage food scientists and researchers. At these events, the best presentations are rewarded with prizes and the opportunity to gain recognition, get feedback on your research and create opportunities to present your work at other UK conferences.

The SCI Lipids Group has hosted the Young Lipid Scientist Award to recognise excellence and emerging talent in research related to lipids, in any field across physics, life sciences and engineering. The Agrisciences Group hosts the Young Researcher of the Year competition, which is open to students or early career scientists researching in biological, chemical, environmental and other relevant sciences, who would like to present their work, learn about recent developments in the sector and meet new talent in agrisciences. The SCI Young Chemists’ Panel, established in 1990, is affiliated with the Fine Chemicals Group and hosts an annual Young Chemist in Industry symposium, which is primarily aimed at chemists working in the pharmaceutical, biotechnology or agrochemical sectors.

There are a number of business and product development focused competitions for the aspiring entrepreneur. Ecotrophelia is a competition that challenges student teams to develop the best innovative and sustainable food products. The UK competition is organised jointly by IFST and Cambria IP and is open to teams of students from UK universities12. The SCI recently launched Bright SCIdea challenge gives students in the UK and Republic of Ireland the opportunity to develop their business skills by turning a science-based innovation into a fully costed business plan. It offers a prize of £5,000 for the winning team with entrants receiving a course of video-based expert training, including advice on: identifying your target market, how to characterise the market need for your product, process or service, scaling up your product, taking your innovation from the lab to the market, managing the finances of a business, protecting your intellectual property and how to produce and present your business in a pitch13.

Getting involved and entering these competitions can reap rewards that are not necessarily obvious at first glance. The people you engage with during the process may be your future friends, mentors, employers, business champions or financial backers! Not to mention the valuable experience and insights you get from taking part. The winners of competitions are typically invited to spend time with the organising groups and are encouraged to be ambassadors for the organisation at their host institutions or workplaces.

**Industry experience**

The importance of a period of experience in industry cannot be overstated, whether you are planning a career in academia or industry. A university career is likely to necessitate either collaboration with industry for funding or imparting industrial concepts and technology to students. Often the gap in understanding between industry and academic partners can be a real barrier to success. Ahead of a move into industry, gaining an appreciation of what you are letting yourself in for will avoid disappointment and the shattering of unrealistic expectations. A try before you buy opportunity shouldn’t be missed. The learned societies and professional bodies are all a great source of industry contacts that may have leads to potential internships and job prospects. The importance of effective networking, face to face, should not be underestimated and participating in events, either as an organiser or speaker, can prove a very fruitful part of your career journey.

**Publishing, conferences and exhibitions**

An academic career necessitates presenting your findings to your peers and obtaining recognition in your field. This can be achieved by publication in a scientific journal or presenting at a symposium or conference. Any opportunity for polishing your presentation skills should be taken. Being able to communicate clearly and sell an idea effectively can be used equally to sell yourself in interviews, secure an investor for your invention, or sell a new food ingredient or processing equipment to your customers.

When working in industry the opportunities for promoting yourself and your work are more limited, so taking the time to submit articles to trade journals, blogs or the company website are worth the effort. Getting involved in early careers activities hosted by the learned societies and professional bodies provides you with opportunities to hone your skills in a risk-free, supportive environment. It could be a precursor of that senior management position that lies ahead of you!  

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Article and references available online at FSTjournal.org/ features/43/4/acroculpia-of-opportunities
Application of ultrasound

The preface to this book explains why ultrasound processing is becoming more important in the food industry. It can be used at higher powers to create changes in structure, temperature increases, homogenisation and food preservation, while at lower powers it can be used for process monitoring and food characterisation.

It is a relatively portable and inexpensive technique compared to some competing technologies. The ability of ultrasound to differentiate between small changes in food structure is also an important feature.

The book has three main parts: the first deals with the fundamental properties of ultrasound, while the second and third consider applications at low and high intensities. This is a good, logical structure. There are 45 contributors covering a wide range of topics.

Part 1, Fundamentals of Ultrasound, contains a description of ultrasonic generation, detection and propagation at various intensity levels. This is a good feature of the book, which will help non-specialists to follow some of the technical content in later chapters. It is at a basic level but more detail of ultrasonic transduction and propagation properties is provided subsequently.

Part 2, Low intensity Ultrasound Applications, represents an in-depth analysis of the ways in which ultrasound can be used to characterise, measure and control processes in food production. It is split into two main parts: Section 2.1 describes the ways in which various parameters of the food can be measured and/or used to control food processing, and Section 2.2 contains more detail of how these measurements can be made in terms of equipment and procedures.

A detailed mathematical study of emulsions and their characterisation is provided, which, although necessary to understand the particle size distribution (PSD) within an emulsion, may be beyond some readers. The main practical description of measurements in broad dough and cake batters, using contacting ultrasonic devices is valuable.

In the flexibility of ultrasound is very well illustrated, showing that various meat products can be measured in terms of fat levels and crystallisation (particularly dry-cured meat products, such as Iberian pork). Other sections consider fat/water content and thermal properties, followed by a discussion of much simpler, liquid-edible oils, which can be characterised using ultrasound.

A detailed mathematical model is proposed for interactions of ultrasound with a complex liquid, the behaviour of the solid being addressed using the extrapolation of temperature and pressure variations can affect a measurement. Section 2.2 contains a very wide-ranging review of air-coupled ultrasonic transducers, which are relevant to many different food-related measurements, where contact with the material is unwanted. Acoustic microscopy is also considered, which allows images of the internal structure of many different food types.

In the Part 3, High-Intensity Ultrasound Applications, Section 3.1 considers ultrasonic applications for liquids at high intensities. The use of ultrasound to inhibit microorganisms and enzymes without changing food structure is addressed, concluding that ultrasound is best used in conjunction with heating. In contrast to this, the deliberate use of ultrasound to change a structure by creating an emulsion and the advantages of ultrasonic processing over alternative emulsification techniques are then discussed.

High-intensity ultrasound (HID) is shown to be useful for creating enhanced osmotic dehydration which, while not able to completely remove moisture from a product, can be used as a pre-treatment before drying by more conventional means.

The use of HIU to extract chemical species from plants as additives to food, herbal extracts etc. is also considered. Both the mechanisms involved and the role of cavitation in ultrasonically-assisted extraction are described in some detail, as are the challenges of integrating such ultrasound techniques within the food and beverage industry.

Section 3.2 considers HIU in applications involving gasses and supercritical fluids. The process of manipulating droplets in air via ultrasonic levitation, translation and mixing is discussed.

This is followed by an analysis of how air-coupled transducers can be used in ultrasonically-assisted drying. A final chapter considers microbial and enzyme inactivation within super-critical fluids. The process of temperature and pressure variations can affect a measurement. The book concludes with a broad scope, taking the reader from the origins of food processing to future possibilities, presenting relatively complex issues in a manner that permits ease of reading and understanding with the ready assimilation of knowledge.

Finally, the use of HIU to change the properties of liquids, including their crystallisation times, resultant microstructure and solid fat content, is addressed along with the extraction and degradation of anthocyanins.

This is an excellent, well-structured book in many respects, covering a wide range of topics related to ultrasound food interactions. All chapters are very well written, with enough technical content to keep the reader interested. A particular feature is the number of references provided for each chapter, which makes the book an up-to-date reference for current research, with sufficient background and links to other work to underpin each specific area.

For those new to the field, this book is very well written by experts in the field and is highly recommended.
Counterfeit spirits are not limited to unlicensed distillers. Even your favorite, top-shelf liquor may be at risk of adulteration and mislabelling. Everywhere we look in industry we see issues with counterfeit, adulterated, or knock-off products. The alcohol industry is no different. Adulterants include both inexpensive solvents for removing paint and ethyl rubbing alcohols with the same intoxicating component as alcoholic beverages (ethanol), but intentionally produced with contaminants (denaturants) to make them unsafe for human consumption. Dating to the prohibition era in the US, cheap and poisonous industrial alcohols often were added to spirits, leading to illness, blindness and death. Similar adulteration practices exist today, with estimates that 30% of the alcoholic beverages consumed in the world are illicit, risking the health of consumers and brand reputation of manufacturers.

Common intentional additives in these denatured alcohols are methanol, methyl-ethyl-ketone and iso-propyl alcohol. Depending on concentration, denaturants are exempt from quality processes and costly taxes, which make them attractive to counterfeiters. Investigation of counterfeit liquors To assist spirits distributors and distillers, reliable spectral sensing technology has been developed to identify counterfeit liquors. Previous studies by Ocean Optics and others have demonstrated that brands of whisky and liquors produce specific UV-visible range spectra, which are useful but not precise enough to differentiate between different alcohols. Here we investigate the feasibility of using a mid-infrared spectral sensor to detect small amounts of denatured alcohol in liquors.

Adison Fryman of Ocean Optics describes the development of a method to detect contaminants in alcoholic drinks.

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Investigation of counterfeit liquors

To assist spirits distributors and distillers, reliable spectral sensing technology has been developed to identify counterfeit liquors. Previous studies by Ocean Optics and others have demonstrated that brands of whisky and liquors produce specific UV-visible range spectra, which are useful but not precise enough to differentiate between different alcohols. Here we investigate the feasibility of using a mid-infrared spectral sensor to detect small amounts of denatured alcohol in liquors.

The new MZ5 spectrometer from Ocean Optics (Figure 1) is a mobile, on-site device that can give real-time results with no sample preparation. The Ocean MZ5 is a miniature ATR spectrometer with measurement capabilities from 1818-909 cm⁻¹ (5.5-11 µm). This fully self-contained instrument -- including sample interface, light source and detector -- provides a compact, fast and scalable alternative to traditional FTIR spectroscopy.

Methodology

For this proof-of-concept stage, methanol (MeOH) and iso-propyl alcohol (IPA) were added to ‘liquor’ samples. These faux liquor samples were a synthetic ethanol-water mixture, akin to
vodka (60% volume ethanol, 60% volume water). Contaminated ‘liquor’ concentrations for each denaturant of 0, 1, 2, 3, 4 (% volume) were created. In just a few minutes several hundred spectra were taken of each sample. These were averaged, and then plotted together to show concentration gradients within the spectral regions for both MeOH and IPA.

Next, spectra for each concentration were subtracted from the average of all contaminated concentrations to amplify regions of variance. Figure 2 highlights the MZ5’s ability to distinguish the absorbance values among IPA samples. What was difficult to discern by eye initially, now appears quite distinct.

A Pearson Product Correlation (mathematical process) study was conducted to identify spectral regions of interest and assess their feasibility for extrapolating trends. In Figure 3, areas where the blue correlation line reaches one or near to one are considered candidates for chemometric development, because they correlate with the concentration values. Areas below zero are regions where the signal correlates negatively with the known concentration. The red spectrum line is shown for visual reference.

Also, based on the regions identified earlier, we built concentration prediction trend validations of the models written using Partial Least Squares (PLS) chemometrics. Several variations at different complexity levels (number of components) were attempted; the ones with the lowest error distribution were selected. The trends were shown to have error below 0.13% (volume), more than sufficient to identify liquors contaminated by industrial grade ethanol.

**Discussion**

Typically, concentrations of around 5% denaturant in pure ethanol are required to qualify as tax-free denatured ethanol and this is meant for industrial use only. Adulterated liquors often contain the maximum tolerable concentration from a safety perspective of 2% denaturant. This is four times the Government recommended amount of 0.5%. While this initial study was limited to synthetic vodka as the ‘liquor’, the accuracy of the results of 0.13% (volume) was five times below the limit needed for identification.

When compared to traditional methods using an FTIR spectrometer with ATR accessory, the MZ5 is more compact, fitting into an easy carrying case. It is more robust, with no moving parts or mirrors that can go out of alignment and is more affordable, at less than half the cost of top-end FTIR systems. Also, the MZ5 can be customised at the point of sale to authenticate liquors, preserving the reputation of the manufacturer, the safety of the consumer and the taxes due to the Government.

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