UK/China Workshop
on Innovative Technologies for the Food Industry

21-22 July 2011

University of the West of England

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Dear Delegate

Welcome to the UK/China Workshop on Innovative Technologies for the Food Industry

This event is part of a BBSRC China Partnering Award which brings together the UK and Chinese academia and industry to address the important issues of development, evaluation and taking to international market novel and rapid technologies for the food industry.

Food quality and safety is one of the top items on the UK, China and international agendas. This workshop aims to initiate discussion for the development of collaborative international projects, staff and student exchange and to form a platform for sustainable long-term collaboration and knowledge exchange in the area of novel technologies.

Alongside oral presentations from the UK and Chinese academia, industry and knowledge exchange organisations, this workshop includes poster presentations, industry exhibition and group discussions and excellent opportunities for networking.

I would like to thank all the contributors, our speakers, sponsors and everybody who was involved in organising this event and made it happen.

I hope you have a productive two days and enjoy this event!

Professor Olena Doran,
Leader of the UK/China Partnership,
Director of Centre for Research in Biosciences

Programme

Day one

09:30 **Registration and refreshments**

09:50 **Welcome** - **Prof Steve Neill**, Deputy Dean, Faculty of Health and Life Sciences, University of the West of England

10:00 **Overview of the UK/China Partnership and Introduction to the Centre for Research in Biosciences** - **Prof Olena Doran**, Centre for Research in Biosciences, University of the West of England

10:30 **Food safety issues in china and abroad** - **Dr Hongyang Wei**, Vice Director of Animal Feed Division in Ministry of Agriculture, China and **Dr Gang Chen**, Institute of Quality Standards & Testing Technology for Agro-Products (IQSTAP), Chinese Academy of Agricultural Sciences (CAAS)

11:00 **Overview of IBST and Introducing technologies for food quality analysis** - **Prof Richard Luxton**, Institute of Bio-Sensing Technology (IBST), University of the West of England

11:30 **Measuring quality in the UK meat industry** - **Kim Matthews**, EBLEX, Agriculture and Horticulture Development Board

12:00 **Lunch**

13:00 **Antibiotic residue in food and feed and testing technology research** - **Dr Gang Chen**, Institute of Quality Standards & Testing Technology for Agro-Products (IQSTAP), Chinese Academy of Agricultural Sciences (CAAS)

13:30 **Sensor systems for early detection of post-harvest spoilage in potato tubers and cereal grain** - **Dr Peter Spencer-Phillips**, University of the West of England

14:00 **Bacterial contamination of feed and feed ingredients – Importance of control for food safety and animal performance** - **Dr Don Wilson**, Global Technical Director, Anitox

14:30 **Refreshments**

14:45 **Development and applications of 3D cell cultures (Spheroids)** - **Prof Simon Jackson**, School of Biomedical and Biological Sciences, University of Plymouth

15:15 **Bioluminescent bacterial biosensors for monitoring food safety** - **Prof Vyv Salisbury**, Centre for Research in Biosciences, University of the West of England

15:45 **Group sessions**

16:15 **Feedback from group sessions**

16:45 **Close day one**

Day two

09:30 **Refreshments**

10:00 **Magneto-immunoassay and impedimetric detection technologies** - **Prof Janice Kiely**, Institute of Bio-Sensing Technology (IBST), University of the West of England

10:30 **Rapid methods for dioxins in food and feed** - **Prof Shuming Yang**, Institute of Quality Standards & Testing Technology for Agro-Products (IQSTAP), Chinese Academy of Agricultural Sciences (CAAS)

11:00 **Spectral and dimensional imaging for food inspection** - **Dr Jiuai Sun**, Centre for Innovative Manufacturing and Machine Vision Systems, University of the West of England

11:30 **Innovation in the animal-derived food production industry** - **Dr David Telford**, Knowledge Transfer Manager, Biosciences Knowledge Transfer Network (KTN)

12:00 **Lunch**

13:00 **Quality assurance from farm to global plate** - **Tim Harrap**, Commercial Manager Export, Adams Foods Ltd

13:30 **Hyperspectral imaging for food quality analysis and control** - **Dr Darren Reynolds**, Centre for Research in Biosciences, University of the West of England

14:00 **Development of a novel device for the detection of organophosphates in food and water** - **Dr Adrian Crew**, Centre for Research in Biosciences, University of the West of England

14:30 **Refreshments**

14:45 **Printed electronic devices: Smart packaging technologies for food quality, safety nutraceuticals and product-enhancement applications** - **Prof Tony Killard**, Centre for Research in Biosciences, University of the West of England

15:15 **Using Innovation in Marketing to fulfill Consumer Demand** - **John Sheaves**, Chief Executive, Taste of the West

15:45 **Funding opportunities and closing remarks** - **Prof Olena Doran**, Centre for Research in Biosciences, University of the West of England

16:00 **Close**

Speakers

Prof Steve Neill

Prof Steve Neill is the Deputy Dean of the Faculty of Health and Life Sciences at UWE, Associate Dean (Planning and Resources) and is also a Professor of Molecular Plant Science. Prior to his appointment as Deputy Dean he was Head of The School of Life Sciences at UWE and the Associate Dean for the Faculty with responsibility for International Development. The Faculty has a number of international partnerships including those with the University of Malaya and other universities and colleges in Malaysia, India, China, Vietnam and the USA.

Prof Olena Doran

Olena Doran is a Professor in Biomedical Research and the Director of the Centre for Research in Biosciences at the University of West of England, UK. Her main research interests are genetics and molecular biology of pathological states and food quality, and development of biomarkers and novel technologies for food quality traits. Her research has been supported by Research Councils, DEFRA, EC and Industry. She has established and developed collaborations with a large number of universities, research institutes and industrial companies in the UK, Europe, China, Malaysia and other countries. Olena has international standing in the area of food quality. She has been acting as a consultant for the EU Working Group of the Standing Committee of the Food Chain and Animal Health and is the Chair of the European Association for Animal Production Working Group on Boar Taint. She is also a member of various international research committees has received a number of prestigious awards.

Dr Gang Chen

Dr Gang Chen got his PhD degree from Swedish University of Agricultural Sciences, and started working in China as a research scientist from the beginning of 2008. His research interests are mainly focused on method development for animal products quality and safety control. Gang has had several publications in international journals and was an invited reviewer for the journal "Drug Metabolism and Disposition". He has participated in several national and international projects, including EU FP6, FP7 programme, and UK/China BBSRC project as PI from China, as well as chief PI in National Natural Science Foundation of China (NSFC).

Prof Richard Luxton

Richard Luxton first studied clinical chemistry in the National Health Service for thirteen years at the Bristol Royal Infirmary before moving to the Institute of Neurology in London to study for a PhD. Richard co-founded the Institute of Bio-Sensing Technology at the University of the West of England, working with Dr Janice Kiely from the Engineering Faculty. The Institute develops collaborations with industry and other Universities through inter-disciplinary research and developing knowledge transfer. A central theme of the Institute is to develop a national and an international collaborative research bringing together expertise from academia and industry. Richard also leads the Biomedical Innovation Network in the Southwest.

Kim Matthews

Kim Matthews began his career with the MLC in 1992 and has built up a wealth of knowledge of the industry, with particular expertise in the areas of carcase and meat quality, and other technical aspects of the slaughtering sector. Since taking on the interim role Kim has proved himself to be very capable of leading the department.

Dr Peter Spencer-Phillips

Peter Spencer-Phillips obtained his BSc in Microbiology and PhD in Plant Pathology at Imperial College, London, before moving to the University of Liverpool as a NERC-funded Research Fellow. He was appointed to a Lectureship in Mycology and Plant Pathology in 1982, and is currently Head of the Department of Applied Sciences at the University of the West of England, Bristol. Research interests include the cell biology of downy mildew pathogens, and the biology and early detection of post-harvest spoilage of fruit, vegetables and grain. International roles have included: Vice-President of the British Mycological Society; editor of the journals Mycological Research, Fungal Biology Reviews and Czech Mycology, and 5 books (CABI, JOLA, Kluwer, Springer); Co-ordinator of the Downy Mildews Working Group, International Society for Plant Pathology.

Dr Don Wilson

Dr J Donald Wilson has been Global Technical Director of Anitox Corporation since 2006. A member in good standing of the Royal College of Veterinary Surgeons (RCVS) since his graduation from the prestigious Royal Dick School of Veterinary Studies at Edinburgh University where he received his Bachelor of Veterinary Medicine & Surgery (the UK equivalent of a DVM), Dr. Wilson has been a practicing veterinary surgeon and obtained extensive experience, comprising more than 30 years, in the poultry and livestock industry. Dr. Wilson has had a remarkable career in the Animal Health field and held a variety of key commercial positions, ranging from technical veterinarian to Technical Marketing Director to Head of Global Animal Science Research, for major Animal Health companies, including Hoffmann La Roche, Hoechst and Agri-Bio. Additionally Dr Wilson is a certified Official Veterinary Surgeon (OVS) of the European Union.

Prof Simon Jackson

Professor Simon Jackson is director of the Centre for Research in Translational Biomedicine at the University of Plymouth and is an associate member of the European Centre for Environment and Human Health at the Peninsula Medical School. He was previously a research leader at the University of the West of England, Bristol and the Medical School, Cardiff University. He has over 180 publications in the area of infection and immunity and has particular expertise in the cell and molecular responses to pathogenic molecules such as lipopolysaccharide. This has included the development of 3D cell models to study infection processes and inflammation and these are being applied in a variety of settings including environmental contamination, pharmaceutical toxicity and food research and the impacts of these on human health.

Prof Vyv Salisbury

Vyv Salisbury is a microbiologist who is involved in applied research with bioluminescent bacterial biosensors. She did her first degree in Microbiology at Bristol University, followed by a PhD in Bacterial Genetics at the Royal Post Graduate Medical School, London University. After a stint of part-time teaching at Luton Tech and the Open University, she returned to Bristol and for many years she worked as a part-time lecturer at Bristol Polytechnic. After her appointment as a full time senior lecturer in 1988, she concentrated on teaching until a chance encounter in 1997 led to the start of the Bioluminescence Applications Research Group. Since then, the group have undertaken a wide range of research projects with research council, industrial, EU and UK Government funding.

In 2003 Vyv obtained Wellcome Trust Engaging Science funding to put on an exhibition in the @Bristol Science Centre entitled "Lighting up biomedical research" with bioluminescent bacteria and flashlight fish. She was also part of the EU framework VII funded 'Bugdeath Project – Predicting the reduction in microbes on the surface of foods during pasteurisation.' In 2009 she got involved with a UN backed project to evaluate medical uses of Himalayan oregano oil which gave her an opportunity to camp up at 3000m in the Himalayas whilst visiting the herb picking cooperative in the Himachal Pradesh.

Prof Janice Kiely

Dr Janice Kiely is the Director of the Institute of Bio-Sensing Technology at the University of the West of England in Bristol.

Janice graduated from Sheffield University with a BEng(Hons) in Electronic Engineering and completed a PhD from Cardiff University in 1992. Her PhD involved the development of novel, miniature thermoelectric devices which could be used for passive IR detection.

For a short time after her PhD, Janice was an engineering specialist at Mewburn Ellis (patent agents) in London and in this capacity was involved in patent prosecution and litigation.

Subsequently, Janice joined the University of the West of England, Bristol as a lecturer specialising in measurement and instrumentation. She has applied this expertise across a number of research fields including power systems and semiconductor device design.

Janice's key research interest involves the development of novel bio-sensing instrumentation. Current key research project areas include the development of immunoassay based measurement system using paramagnetic particles as labels.

Dr Shuming Yang

Dr Shuming Yang is a research professor and division director of IQSTAP and a member of CAC-China steering committee on veterinary drug residues. As a Principal Investigator, he is coordinating several national key research projects on screening techniques and national standards methods for veterinary medicine and illegal drug residues. He has developed methods for detecting Sudan red, melamine, clenbuterol, furazolidone which were accepted and published by regulatory authorities as national standards in China. At present, he is focused on molecular detection method for multi- ß-agonists based on reconstructed receptor protein as biosensor, ELISA kits for detecting 6 compounds of veterinary medicine residues and 2 compounds of synthesized pigments in food, molecular detecting method for dioxin, and quantity and confirmatory analyzing feed additive and veterinary drugs in feeds and animal products.

Dr Jiuai Sun

Dr Jiuai Sun works as a Research Fellow within the Machine Vision Laboratory, Faculty of Environment and Technology, at the University of the west of England in Bristol. He is interested in characterizing the dimensional and spectral characteristics of object surfaces through novel imaging techniques, and exploring new applications in healthcare, food and other industrial sectors.

Dr David Telford

David has a first degree in Agriculture from the University of Newcastle, and a PhD in bio-economic modelling of a new technology applied to the UK cattle industry. His interest in agriculture stems from being brought up on a beef and sheep farm. David previously worked for the Genesis Faraday Partnership, helping to stimulate knowledge transfer between the science base and the animal breeding and animal health industries. As part of this role, he helped facilitate many different collaborative projects in both the UK and internationally, and has substantial experience of helping source funding for such collaborations, including large-scale European projects.

David has worked for the Biosciences Knowledge Transfer Network (KTN) since its establishment in September 2009. The Biosciences KTN is funded by government to drive the conversion of the UK's bioscience knowledge into innovative agricultural, food and industrial bioscience products and processes. David works in the Animal Sector team within the KTN, and other sectors assisted by the KTN are the plant, food and industrial biosciences. The Animal Sector activity builds on the successful Genesis Faraday network and comprises around 100 member organisations working in the animal biosciences, from both the research base and industry.

Working as a Knowledge Transfer Manager at the Biosciences KTN, David has gained an excellent understanding of the science base and the commercial sector, a broad knowledge of cutting-edge technology, substantial experience of establishing collaborative research and knowledge transfer projects, and facilitating appropriate funding to allow such cooperation.

Tim Harrap

Tim Harrap is the commercial manager (export) of Adams Foods. Mr Harrap has been working in the dairy industry and international trade since 1991. He has worked on dairy farms, in cheese making plants and for the last 15 years on international markets. He has introduced British food brands to over 50 markets worldwide working with importer/ distributors, retailers and manufacturers.

Dr Darren Reynolds

Darren Reynolds has a degree from the University of Plymouth in Environmental Science, specialising in Environmental Chemistry. He did a PhD at RMCS, Shrivenham (Cranfield University) looking at water quality monitoring using laser spectroscopy.

Darren has been a Principle Lecturer in Environmental Sciences and Environmental Health within the Faculty of Health and Life Sciences at the University of the West of England since 2000. He has over 14 years experience in developing technologies for solving environmental problems, including environmental monitoring and environmental decontamination.

In 2006, Darren was awarded a 3-year research grant (Home Office, CBRN program) concerning the Chemical and Biological Decontamination of People, Structures and the Environment Using Electrochemically Activated Solutions. This project worked closely with the Government Decontamination Service to characterise a novel point of use decontaminant and also develop methodologies for the real-time in-situ monitoring of fast acting disinfectants. This work has led to further industrial support for the development of a novel decontaminant for a range of industrial applications.

Dr Adrian Crew

Adrian first became involved in a number of academic and commercial agro-environmental research projects in 1994, mostly based on the cycling of agrochemicals in the environment. His doctorate was quite different in that it involved the design and development of industrial bacterial fermentations for a large alcoholic drinks manufacturer. Having a foot in industry and another in academia helped him enormously when he started working with Prof John Hart in the Centre for Research in Biosciences at the University of the West of England, developing electrochemical sensors and biosensors. For the past seven years, Adrian has been involved with projects developing sensors for a wide range of agrochemical, environmental and biomedical applications for a number of governmental and industrial sponsors.

Prof Anthony J Killard

Prof Tony Killard is Professor of Biomedical Sciences at the Centre for Research in Biosciences (CRIB) at the University of the West of England in Bristol. He graduated top of his honours degree class in Microbiology in 1993 at Trinity College, Dublin, where he was recipient of the Guinness, F.S. Stewart and Smithkline Beecham Prizes. He received his PhD in Biotechnology at Dublin City University in 1998 under Professor Richard O'Kennedy (BSc, PhD) for which he was awarded the Chancellor's Medal.

He has held a variety of posts both within academia and industry. He has worked as a lecturer in the School of Chemical Sciences at DCU as well as Development Scientist at Inverness Medical Ltd where he specialised in the development of immunosensor and immunodiagnostic transduction platforms. He began a Senior Research Fellowship at Dublin City University in January of 2004 and was a founding Principal Investigator of the Biomedical Diagnostics Institute (BDI) in 2005 where he developed a range of biomedical diagnostic devices including blood coagulation monitoring and diagnostic breath monitoring devices. He was also a Principal Investigator at the National Centre for Sensor Research where he developed extensive expertise in the area of electrochemical sensors and biosensors, particularly on the development and application of conducting polymer nanomaterials, coupled with production technologies such as inkjet printing.

Tony took up the post of Professor of Biomedical Sciences at UWE in January 2011 where he is continuing to develop diagnostic device technologies based on microsystems and printed electronics integration. He currently coordinates an FP7 consortium on the development of diagnostic devices using printed electronics.

John Sheaves

John Sheaves is the Chief Executive of Taste of the West. John was brought up on a small Devon dairy farm. He farmed for 15 years - outdoor pigs, sheep and arable - and set up East Devon's first farm shop. He then moved into the environmental sector advising farmers in Dorset on how they could introduce environmental principles into their farming businesses. John then managed an environmental consultancy for 5 years before joining Taste of the West as its Chief Executive in 2005.

John has always felt that marketing and correct product branding are the keys to a successful farming industry here in the south west and Taste of the West is the ideal vehicle to take these ideas forward. Taste of the West has been instrumental in forming and developing a regional food culture in the south west of England based on Local Provenance, Integrity and Quality as benchmarks for the new culture.

Speaker Abstracts

Overview of the UK/China Partnership and Introduction to the Centre for Research in Biosciences

Prof Olena Doran, Centre for Research in Biosciences, University of the West of England

The UK/China partnership for innovative technologies for detection of environmental pollutants in animal feed and animal-derived food has been established under a Biotechnology and Biological Sciences Research Council (BBSRC) China Partnering Award. The main aim of this partnership is to establish a sustainable network and long-term collaboration between the UK and China in order to develop, evaluate and take to the market new, rapid and cost-effective technologies. Specific objectives include organising bi-lateral workshops, developing a long-term programme for staff and students' exchange; and developing a programme for long-term research collaboration and networking. The initial project partners are: (i) Centre for Research in Biosciences, University of the West of England (UWE), UK; (ii) The Institute for Quality Standards and Testing Technology for Agroproducts, Chinese Academy of Agricultural Sciences (CAAS) ; (iii) Institute of Bio-Sensing Technology, UWE, UK; (iv)College of Animal Science and Technology, China Agricultural University ; (v) Machine Vision Laboratory, UWE, UK; (vi) National Animal Feed Inspection Centre in China, CAAS and (v) University of Plymouth. The partnership is open to academic, industrial and other organisations in the UK and China. It is anticipated that the Partnership will develop platform technologies which could be used for wider applications.

The Partnership is led by the Centre for Research in Biosciences at the University of the West of England which brings together world class researchers with a focus on four main research themes: biomedicine, bio-sensing technology, plant science and environmental science. The Centre addresses both fundamental and applied aspects of research and the Centre members have close links with national and international academic partners, industry, health organisations and end users to ensure that the research has real social and economic impact. The centre has a strong focus on collaboration and partnership. Its international links include collaborations within Europe, Malaysia, China and USA. The Centre research and knowledge exchange activities are supported by funding from UK Research Councils, national and international charities, British Council, industry, EU funding and other. Further information about the Centre for Research in Biosciences can be found at **http://www1.uwe.ac.uk/hls/research/biosciences.aspx**

Food safety issues in China and abroad: Emerging problems in global food safety

Dr Hongyang Wei, Vice Director of Animal Feed Division in Ministry of Agriculture, China and Dr Gang Chen, Institute of Quality Standards and Testing Technology for Agro-Products (IQSTAP), Chinese Academy of Agricultural Sciences (CAAS)

The globalization of the food trade market has attracted great interest from both producers and consumers worldwide. However, as international food trade has grown, the frequency of food safety incidents have seriously threatened consumers' health and gravely affected the confidence for consumers' consumption, which is the driving force for the sustainability of the food trade market. A consequence of every food safety crisis is the significant economic loss to the industry, as well as the decline of trust in the government. Food safety issues not only affects individuals, but also strongly impacts society worldwide, and this is the double-edged sword of food trade globalization.

An emerging food crisis which is caused by food-borne disease and chemical contamination is not only occurring in developing states but also in developed ones - its influence has crossed the geopolitical boundaries of sovereign states. After the first case of BSE cow found in 1984, more than 30 other countries and 188,579 new cases have been reported. The incident of dioxin contaminated poultry feed firstly happened in 1999, again occurred in North Ireland last year. Sudan red contaminated foods which covered large kinds foods including world well-known labels such as KFC were detected in UK, China and other countries. In 2007, the US recalled the melamine contaminated pet feed in which the raw material was imported from a Chinese company. Later in 2008, a high content of melamine was found in infant formula and caused fatalities and illness to Chinese children and the biggest Chinese dairy company collapsed because of this.

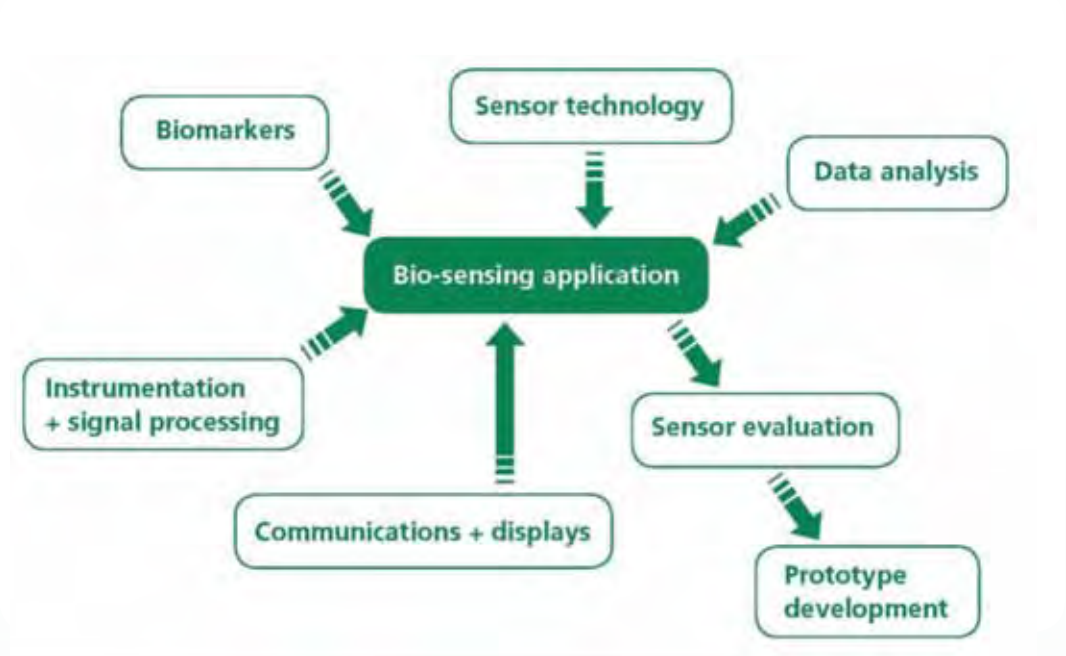
Joint efforts have been pursued worldwide to tackling the global food safety crisis. International bodies such as WHO, FAO and OIE have worked efficiently to ensure food safety globally. Codex Alimentarius Commission (Codex) develops standards for food in order to protect the health of consumers and fair practices in the international food trade. Within each nation, each government has their own structure to secure food safety. However, food safety issues are so complex and impossible to be solved totally and this has become a long term battle that we need to fight for. Here we give an example of the Chinese government reaction to the food safety issue. After the melamine incidence, in order to regain the consumers' trust to domestic dairy industry, Chinese government has published a new law for ensuring food safety. Also a new government body entitled "Food safety and food hygiene risk assessment committee" has been established. Quality surveillance system have been further strengthened. All of the enterprises have been installed with new equipment for quality control of collected raw milk.

Thinking about the future, we can imagine a new crisis of food safety will emerge, as well as the spread of the threat to public health beyond the territorial boundaries of nation-states. However, it is of utmost importance to highlight the global efforts in facing of the challenge. We need to extend collaborations and communications in information and detecting techniques etc., to tackle the issue and we need to work together to protect our health.

Overview of the Institute of Bio-Sensing Technology and Introducing technologies for food quality analysis

Prof Richard Luxton, Institute of Bio-Sensing Technology, University of the West of England

The Institute of Bio-Sensing Technology was developed over two years and launched in 2008 to bring together academic and industrial partners to create new bio-sensing technologies. We define bio-sensing very broadly and by consolidating talents and experience from across a range of subject areas we are able to respond to larger challenges presented by industry and public sector. This breath of discipline areas that contribute to the development of a bio-sensing system is shown in the diagram below.



Through this kind of collaborative working the Institute is well placed to take an idea from conception, through fundamental research and development to pre-production prototype, in preparation for exploitation.

This broad approach to bio-sensing technologies gives an insight of how different technologies can be integrated or transferred from sector to sector to address specific needs. This talk will give an overview of innovative technologies that are, or could be, used in the food quality and safety landscape and identify where particular technologies are being used, giving a context to other talks being given at this workshop. In addition, this talk will identify areas where there is scope for innovation and development of new technologies for use in the food industry which could lead to the development of new partnerships to address issues in these areas.

Measuring quality in the UK meat industry

Kim Matthews, Agriculture and Horticulture Development Board

The term "quality" incorporates a wide range of attributes of meat that influence the individual or group decision on whether a particular piece of meat is suitable to eat and a delivers a pleasant experience when consumed. Several components of quality are not suited to physical or chemical measurement – being associated with religious, ethical or social influences on which types of meat, if any, are considered acceptable.

The potentially measurable aspects of meat quality (including carcase quality) will be the focus of this paper.

1. Carcase quality is essentially the assessment of the yield of lean meat from a carcase. Carcase weight is an obvious measurement but in addition some assessment of the composition is required. This has been achieved largely through assessment of fatness and, to a degree, shape of the carcase. In pigs, where subcutaneous fat is a good indicator of total fat, a simple fat depth measure can be used, with carcase weight to estimate lean meat percentage. A wide range of other methods is also available using reflectance probes or ultrasound. In cattle and sheep it has proved difficult to find a suitable objective measure for carcase quality and an assessment of shape and fat cover is used, either by eye or using video image analysis.
2. Composition. The grass composition is assessed at the carcase level. It is however, of interest to assess the specific fat content of individual cuts or products. A wide range of tools is available for assessing total fat content. Of more recent interest is the measurement of fatty acid composition. This is more challenging and it is not yet routinely measured on-line. Some technologies are providing promise in this area.
3. pH. The pH of meat, and its rate of change, can be a good indicator of various quality problems that can arise. A range of commercial pH probes can be used to measure this.
4. Colour. Meat colour is important in determining the visual appeal of a cut of meat. In some countries it is used as part of a grading system for quality, although it relates poorly to eating quality. Various tools can be used to measure colour but these are generally not used routinely.
5. Toughness/Tenderness. Tenderness is widely considered the most important eating quality characteristic meat. Various techniques, usually based around measures of sheer force, can be used "near-to-line" for process monitoring. It has proved more challenging to develop an on-line technique. Progress in this area, in particular using Near Infrared Reflectance Spectroscopy, will be discussed.
6. Flavour. Meat flavour is extremely complex. Nevertheless there are potential targets for sensors (the flavour precursors) but little has been done in this regard. Off-flavours, on the other hand, are generally more specific and therefore simpler targets for detection. Boar taint is probably the most well known such problem. The compounds responsible are not yet routinely detected on-line.

In conclusion, meat quality is complex and while there are opportunities for measurement, there is tremendous scope for further development in this area.

Antibiotic residue in food and feed and testing technology research: Investigation of antibiotic resistant bacteria strains in Chinese pig and poultry farms and slaughterhouses

Dr Gang Chen, Institute of Quality Standards & Testing Technology for Agro-Products (IQSTAP), Chinese Academy of Agricultural Sciences (CAAS)

Antibiotics have been widely used especially in developing countries lacking relevant regulations or an efficient approach to control their use. A direct consequence of this is the emergence of resistant bacteria, which are more powerful and more difficult to eradicate. Great amounts of antibiotics are still used in farm animals for therapy or even for growth promoting purposes. The antibiotic residue can be released into the environment through manure and drinking water and changes the microbial ecosystem and reduces the capacity of plants preventing pathogen. Antibiotics also accumulate in animal products and harm human health via the food chain. Moreover, abuse of antibiotics in animal husbandry has caused more frequent disease outbreaks and is more expensive to control as noted in WHO.

Antibiotics are commonly used in Chinese poultry and pig farms for preventing disease and for therapy. The main antibiotics include βlactams, quinolones, aminoglycosides, tetracycline, sulfonamides, and macrolides. However, as bacteria resistance to antibiotics becomes more and more serious, alternative ways must be pursued. Currently, the alternative approaches include: (1) Developing new antibiotics to compete with bacteria resistance, however, even this is short-sighted but propelled for economic reasons; (2) Better management system for scientifically using antibiotics, e.g. using a combination of two more antibiotics simultaneously; (3) Chinese herbal medicine (CHM) has been reported effective for treating bacteria disease without inducing resistance - it can either induce the sensitivity of bacteria to antibiotics or reduce its resistance. Therefore, the combinational application of CHM and antibiotics is very promising for preventing bacterial resistance.

Scientific research includes the following aspects: (1) Bacteria resistant strains and antibiotics in pig and poultry farms. We investigated the resistance of E. coli and salmonella isolated from animal faeces in farms and intestines in slaughterhouses to the following antibiotics: ß-lactams, quinolones, aminoglycosides, tetracycline, sulfonamides, and macrolides; (2) Resistance development and environmental influence; (3) Mechanism of bacteria resistance occurrence, keeping and transfer.

Sensor systems for early detection of post-harvest spoilage in potato tubers and cereal grain

Dr P T N Spencer-Phillips, Dr B P J de Lacy Costello, Dr R J Ewen, Prof N M Ratcliffe, Department of Applied Sciences, University of the West of England

A prototype sensor system for the early detection of ***Pectobacterium*** (previously known as *Erwinia*) soft rot in potato tubers has been developed (de Lacy Costello et al., 2000 & 2002), and assessed in potato store trials to provide 'proof of principle' evidence for its applicability as a disease detection technology. The system operates by the automated collection of air samples from selected areas of the store, and passing the air to an electronic nose (e-nose) containing a set of ceramic sensors selected for their sensitivity to marker volatile organic compounds (VOCs). The resulting data are captured, displayed and recorded by computer. The basic principles of the technology are introduced, and some aspects of the in-store trials presented. Conclusions are drawn about the potential application of this approach for detecting post-harvest spoilage of bulk plant produce, where advance warning of early stages of disease provides the opportunity either to change store conditions to control the problem, or to advise on quality and marketing strategy.

The prototype system has proved itself to be effective and reliable, and there is also much potential for variants to be used for other bulk plant produce, such as cereal grain. The application of the device for assessing the quality of wheat grain (de Lacy Costello et al., 2003) will also be summarised.

de Lacy Costello BPJ; Ewen RJ; Gunson HE; Ratcliffe NM; Spencer-Phillips PTN (2000). The development of a sensor system for the early detection of soft rot in stored potato tubers. *Measurement Science and Technology* 11, 1685-91

de Lacy Costello BPJ; Ewen RJ; Gunson HE; Ratcliffe NM; Spencer-Phillips PTN (2002). Sensors for early warning of post-harvest spoilage in potato tubers. In: Pests & Diseases 2002, Vol. 1, pp. 425-32. British Crop Protection Council, Brighton, UK

de Lacy Costello BPJ; Ewen RJ; Gunson HE; Ratcliffe NM; Sivanand PS; Spencer-Phillips PTN (2003). A prototype sensor system for the early detection of microbially linked spoilage in stored wheat grain. *Measurement Science and Technology* 14, 397-409

Bacterial contamination of feed and feed ingredients – Importance of control for food safety and animal performance

Dr Don Wilson, Anitox Corp

Animal feeds can serve as a carrier for a range of microbial contaminants such as moulds, mycotoxins and bacteria. Such contaminants have been shown to influence animal performance adversely and to compromise the safety of animal products. Whereas the importance of controlling moulds and mycotoxins in feed is widely known and practised, control of bacteria is less well understood and frequently overlooked. This presentation will examine bacterial contamination of feed ingredients, as well as the potential for contamination and recontamination of feed during processing and delivery to the animal. Measures to control bacteria in the feed, their technological and economic advantages and importance for animal performance and food safety will also be reviewed.

Feed ingredients and complete feeds contain a wide variety of bacterial species, some of which are pathogenic to humans and animals. Examples of pathogenic species found in feed are Salmonella, E.coli, Staphylococcus, Streptococcus, Pasteurella, Pseudomonas, and Clostridia.

Feed ingredients can become contaminated at any time during growing, harvesting, processing, storage and delivery to the feed mill. Contamination can occur through direct or indirect contact with the environment, or through cross-contamination with already contaminated ingredients. The primary sources of direct environmental contamination are soil, rodents, wild birds, predators, insects and dust. Indirect contact is through contaminated water, sewage or animal manure used in the fertilisation of crops.

Animal feed contaminated with bacteria pathogenic to humans can contribute to human food borne illness through the feed-animal-food-human chain. Humans can be exposed to such pathogens by consuming improperly prepared eggs, meat or milk from infected animals or from foods contaminated by the faeces of infected animals.

Measures to control bacteria in feed are, therefore, essential. Chemical treatments, which not only control bacteria but also prevent recontamination until the point at which the animal eats the feed, may offer one solution. Such treatments have also been shown to give consistent improvements in animal performance. Rather than being seen as an extra cost, bacterial control in feed should therefore be seen as a method of improving the economic performance of a farming enterprise.

Developments and applications of 3D cell cultures for food research (Spheroids)

Prof Simon Jackson, Director, Centre for Research in Translational Biomedicine, University of Plymouth, Plymouth, UK.

The development and validation of reliable in vitro methods, that offer an alternative to conventional in vivo studies in experimental animals, is a well-recognised priority in the fields of pharmaco-toxicology and food research. However, conventional studies based on two-dimensional (2-D) cell monolayers have demonstrated significant limitations: Cells grown on flat 2D tissue culture substrates can differ considerably in their morphology, cell-cell and cell-matrix interactions, and differentiation from those growing in more physiological 3D environments. Another fundamental problem in isolated primary cell monolayer cultures is the loss of differentiated functions after isolation and during in vitro culture. Furthermore, such monolayer cultures can only be maintained for 2-4 days. Development of suitable 3D cell cultures that mimic in vivo cell behaviour and functions is thus a desirable approach to overcome problems with 2D cultures and to reduce the use of animals.

We have developed a method of culturing primary cells and continuous cell lines as 3D constructs (spheroids) that retain functions and metabolic activity characteristic of in vivo tissue, and are thus an excellent experimental model and a valuable in vitro tool for studying cell behaviour and function in a variety of settings. For example, we have demonstrated that spheroids grown by our gyrotatory method from rat liver tissue or HepG2 human hepatocyte cell lines, reach a functional maturity by 5 days in culture, attain a size of 200±25µm in diameter and remain functionally active for at least 21 days in culture. Our previous and recent work has shown that liver spheroids grown under these conditions have hepatocytes in a true 3D configuration that results in excellent regain and retention of differentiated hepatocyte functions, including CYP activities. We have found that spheroids grown from hepatocytes are useful models to study physiology and pathophysiology of liver. This is particularly important for analysing functional and morphologic changes in liver over longer time periods such as in chronic toxicity testing.

This talk will outline the methods and applications of our 3D cell culture models utilising both animal and human cells. Moreover, our recent developments of spheroid cultures of fish cells will provide important models for environmental toxicity testing and for aquaculture. There is an urgent need for validated human-derived in vitro test models for food technology. For example in the early prediction of food/nutrient quality, the potential health effects of food and dietary supplements and for evaluating food contaminants. The need to develop appropriate and standardised methods for the analysis of food components efficacy and safety for human health is a high priority and such 3D cell models will be powerful functional tools for the rapid detection of hazards and threats associated with food, agriculture, environment and biosecurity.

Bioluminescent bacterial biosensors for monitoring food safety

Prof Vyv Salisbury, Centre for Research in Biosciences, University of the West of England

Bacteria expressing *lux* genes have been employed as real-time, ***in-situ*** reporters of the effects of food surface pasteurization processes within the 'Bugdeath' programme for predicting microbial death during heat treatments on food. Food borne pathogens were transformed with plasmids carrying lux genes, in order to cause minimum alteration of the bacterial phenotype. The plasmids all carry the luxCDABE genes from Photorhabdus luminescens, controlled by a constitutive promoter; however different vectors were used to give stable lux gene expression in Escherichia coli O157, Salmonella typhimurium DT104 and Listeria monocytogenes Scott A. The bioluminescent reporter constructs were monitored in nutrient media over 24 hours and showed good correlation between bioluminescence and growth. For assessing heat inactivation and recovery, S. typhimurium DT104 pGLITE was inoculated onto food surfaces at 105 cfu/cm^2 and exposed to dry heat treatments, raising the temperature of the food surface from 4°C to 90°C over 30-40 seconds and holding for 3 minutes. For wet heat treatments steam was passed over the food surface for 1 minute. Bioluminescence was monitored throughout heating, using a photon counting camera. The bacterial regrowth, after heating, was monitored, positionally and in real-time, by light output at room temperature for up to 24 hours. Bioluminescence declined at a constant rate as the temperature increased above 32°C for all foods tested. It then remained below detection level throughout the period of heating. The 90°C dry heat treatment had only a limited cidal effect on S. typhimurium adhering to different food surfaces, causing 6-7 hours of metabolic inhibition on vegetables and chicken. This period increased to 9-18 hours for all other meat samples. Steam treatment prevented bacterial recovery for at least 24 hours on all food surfaces tested. Bioluminescence monitoring indicates steam is significantly more effective at preventing bacterial recovery than dry heating at a similar temperature.

Magneto-immunoassay and impedimetric detection technologies

Prof Janice Kiely, Institute of Bio-Sensing Technology, University of the West of England

Two electromagnetic-field-based measurement technologies with potential for application in the food industry are described.

Firstly, a new, high accuracy paramagnetic particle detection system for quantifying binding in a magneto-immunoassay is discussed. The system comprises a resonant coil and a detector circuit and facilitates the complete immune reaction and binding measurement to be carried out in a miniature test vessel. The resonant coil is designed to have a highly localized field distribution and is positioned adjacent to the reaction surface of the test vessel. The paramagnetic particles that are bound to the reaction surface, influence the electromagnetic field of the coil and cause a change in the inductance. A detector circuit based on a novel frequency-locked-loop arrangement performs the resonant frequency measurement to register this inductance change. Using the single step process, a binding assay can be performed in under 3 minutes. The system has been used to measure a range of analytes include CKMB, CRP, PSA and bacteria i.e. E-coli and C.difficle.

Secondly, a novel impedance analysis system for identifying and characterizing toxins applied to a cell culture is described. Cells are grown in standard multi-well culture plates and continuous, real-time electromagnetic measurements are made via electrodes linked to a lock-in amplifier. Physiological processes within the cells alter when the cells are faced with a toxic challenge and result in variation in the impedance values as a function of frequency and time. Sophisticated data analysis techniques are applied to the output impedance data to provide feature extraction to allow classification of the cellular response to different concentrations and types of toxin. The Hilbert Huang Transform algorithm is compared with Wavelet Packet Decomposition approach to establish the optimum classification methodology.

Rapid methods for dioxins in food and feed: The chemically activated fluorescent gene expression system for dioxins detection in feed

Prof Shuming Yang, Institute of Quality Standards & Testing Technology for Agro-Products (IQSTAP), Chinese Academy of Agricultural Sciences (CAAS)

The occurrence of dioxin contamination to food and feed has aroused world-wide concern, especially after the dioxin food crisis in Belgium in 1999. A highly sensitive method for analyzing dioxin residues in food and feed is required for food safety inspection purposes. In general, the developed methods for dioxin analysis can be classified as: 1) chromatography, e.g. HR-GC/MS, 2) immuno-assay, and 3) bioassay. At present the HR-GC/MS method is the golden method for dioxin contamination analysis in food and feed but developing a method which can achieve high throughput and low cost is needed.

The study aimed to establish a bioassay system for dioxin analysis based on its AhR-dependent mechanism of action, which can be a rapid, low-cost and sensitive screening method. We constructed an expression vector pGMD1.1, which includes dioxin response element (DRE), mouse mammary tumor virus (MMTV) promoter and EGFP (Enhanced Green Fluorescent Protein) reporter gene. We transient transfected the recombinant plasmid into the rat hepatoma (H4IIE) cell line, and the cells were induced by TCDD and DMSO, respectively. The result showed that the TCDD induced cell line had higher EGFP relative fluorescent units (RFU) compared with control (DMSO reagent). This shows that the reconstructed plasmid works for the dioxin analysis.

Further, we tried to establish a stably transfected cell line based on the constructed plasmid and H4IIE cell line. The cells were incubated under the antibiotic (geneticin, G418) selection. The cell clones resistant to antibiotic were isolated and screened for the induction of EGFP expression by TCDD (1 nM for 24 h). Clone exhibiting the highest induction of EGFP expression was further characterized. For the dioxin induction analysis, we incubate the stably transfected cell line with TCDD in DMSO at the concentration from 1 pM to 10 nM. The RFU exhibited TCDD dose-dependent response and there is good linearity between RFU and TCDD concentration. The highest induction can reach 10 times higher compared with control (stably transfected cell line incubated with DMSO reagent). The minimal detection limit (MDL) was approximately 1 pM, EC50 was about 5 pM, and the maximal induction was about 500 pM. In conclusion, we have successfully established the dioxin bioassay system. More method optimization needs to be done, especially the stability of analysis between batches, the interfering analysis by other chemicals, and the sensitivity of the method needs to be improved.

Spectral and dimensional imaging for food inspection

Dr Jiuai Sun, Centre for Innovative Manufacturing and Machine Vision Systems, University of the West of England

The external characteristics of food products, such as size, shape, colour and texture, are important factors useful for assessing the quality of food items. Currently these visual aspects are normally assessed or graded through visual appraisal by trained staff. However, this approach is unavoidably subjective and inconsistent. This lack of, objectiveness, repeatability and accuracy is due to the inherent variation and limitations of human visual sensing system. This leads to an interest in the employment of computer vision techniques to improve upon the limited capability of human visual judgement alone.

Most computer vision based techniques give an evaluation of food quality through capturing and analyzing colour images of the food surface. Unfortunately a physical colour qualification from an optical sensor is environment dependent and may deviate from that of human psychophysical perception. Any environmental difference, caused by lighting temperature and spectrum, sensor sensitivity and relative pose between lighting and objects, can result in a significantly different colour impression. In addition, the inspected surfaces of food (especially fresh meat) will have changed in their reflection characteristic after being slaughtered bleeding and exposed to the external environment. This may weaken the correlation between external image markers and the internal biological structure.

The presentation will introduce a new imaging model which covers not only the normal visible colour spectrum, but also the invisible infrared spectral range, to allow inspection of deeper structures under the surface non-destructively. Our new imaging modality is also designed to recover the surface 3D topography at high-resolution and so adds an extra dimension for food quality inspection. Finally, several demonstrations on meat and vegetable examples will be used to show the potential of this imaging modality for the research and development of new assessment techniques within the food industry.

Innovation in the animal-derived food production industry

Dr David Telford, Knowledge Transfer Manager, Biosciences Knowledge Transfer Network (KTN)

The UK has a long and successful history of producing animals for food, and the UK is still home to some of the largest and most successful animal production companies in the world. Much of this success has been due to the adoption of new innovative technologies.

The Biosciences KTN is funded by government to drive the conversion of the UK's bioscience knowledge into innovative agricultural, food and industrial bioscience products and processes. This presentation will provide an insight into some of the latest innovations that are being used in the UK animal production industry today.

Quality assurance from farm to global plate

Tim Harrap, Commercial Manager – Export, Adams Foods Ltd

- **The geography and context of the British Dairy industry**
- **Farm level quality testing and assurance** – farmer and buyer perspectives
- **Elements of food safety in UK cheese production and packing** – BRC, Red Tractor assurance, supermarket quality schemes
- **International trade quality assurance** – UK Animal Health.
- **GI Products Quality Assurance** – the case of West Country Farmhouse Cheddar in China part of 10+10

Hyperspectral imaging for food quality analysis and control

Dr Darren Reynolds, Centre for Research in Biosciences, University of the West of England

The use of hyperspectral imaging for remote sensing applications is well known. However, the increasing availability of hyperspectral imaging systems to the wider scientific community has resulted in rapid advances in the application of this technique to a wide variety of scientific disciplines. Commercially available systems that are compact, rapid, versatile and complimentary with other technology platforms allow the collection of spectral rich images of objects as a function of both time and space at micro and macro dimensions. The image below represents the type of image that can be rapidly acquired using hyperspectral imaging systems. The highlighted regions of interest (1, 2 and 3) represent three different bacterial colonies on an agar bacterial plate. Each colony exhibits unique spectral properties which can be assigned using 250 contiguous bands in the region between 400-1100nm.

This presentation will give an overview of some recent applications of hyperspectral imaging for food quality analysis and control. Emerging areas of research which are of particular relevance to the food industry, specifically the detection and identification of bacteria on fresh produce, will be explored. Preliminary data of on-going research being undertaken at the Centre for Research in Biosciences (UWE, Bristol) concerning the identification of bacteria on food surfaces using a combination of hyperspectral imaging and multidimensional scaling and statistical classification will be presented.

Development of a novel device for the detection of organophosphates in food and water

Dr Adrian Crew, Centre for Research in Biosciences, University of the West of England

Organophosphate pesticides (OPs) are widely used in agriculture and veterinary treatments due to their high efficiency as insecticides. Unfortunately, they have been shown to be highly toxic with the majority being hazardous to both human health and to the wider environment. Indeed, the inhibition of the neurotransmitter acetylcholinesterase (AChE) by OPs can lead to a disturbance of normal neuronal function and possibly death. As a consequence of this, there have been growing concerns related to the possible contamination of the environment by these compounds and increasingly stringent regulation at national and European level.

A consortium of academic partners, component manufacturers and end-users were led by UWE in designing and developing a generic automated system capable of the rapid identification and quantification of specific OP residues in water and food samples. The resulting prototype instrument incorporates an electrochemical biosensor array based on screen-printing technology using commercially available materials to allow mass production at low cost. The proposed biosensors are comprised of a layer of AChE obtained from *Drosophila melanogaster* and immobilised onto the surface of screen-printed carbon electrodes modified with the electrocatalyst cobalt phthalocyanine. AChE is inhibited by the OPs leading to a reduction in the current produced, which is the basis of the assay. In the present development, optimisation studies have been carried out to develop a biosensor array based on various forms of the AChE to enable a neural network to learn the specific inhibition characteristics of each enzyme. From this, the neural network can accurately predict the identity and concentration of an OP present in the sample. The new prototype system has been evaluated for operation in the field with a selection of OPs of importance in environmental and food monitoring. This presentation will discuss the development of our automated system, the feasibility of identification of OPs in real samples in diverse monitoring locations and the future development and exploitation of the analytical system.

Printed electronic devices: Smart packaging technologies for food quality, safety nutraceuticals and product-enhancement applications

Prof Anthony J. Killard, Centre for Research in Biosciences, University of the West of England

The emerging field of printed electronics is changing the way in which we use technology. The low cost, flexible, mass producible and disposable nature of such technologies lends them well to many potential applications, including innovations in the food industry such as smart packaging. Significant added value is created when a characteristic of the food can be measured. This characteristic may either be a physical, chemical or biological property of the food itself, or a result of the effect of the food consumption in innovative foodstuffs such as nutraceuticals.

This talk describes a range of emerging printed electronics-based chemical and biosensing measurement technologies and envisages how these and similar devices may be applied to food technology and innovation.

Food packaging is increasingly being used as a means of indicating food quality. Low cost, printed sensors have the ability to monitor food packaging atmosphere for changes to chemical composition which may be indicative of degradation. This is particularly so of proteinaceous foods such as meat, but also extremely important in high value, high safety products such as baby foods and formula. Contactless techniques using passive RFID monitoring can enable remote measurement at low cost, while allowing supply chain control and management of the information generated.

Printed electronics also offers the opportunity to innovate in other product areas which enhance purchase experience. For example, chewing gum and breath freshening products could be sold with devices for measuring breath freshness with the so-called 'kissability' sensor.

Food products are also now offering improved health through nutraceuticals that, for example, control cholesterol levels. Printed electronic devices that can measure cholesterol may become accompaniments to the sale and distribution of such food items.

Using Innovation in Marketing to fulfill Consumer Demand

John Sheaves, Chief Executive, Taste of the West

First, two facts:

- Britain... imports 40% of the total food consumed and the proportion is rising.
- The South West region is economically linked to the national food supply chain. Therefore anything which affects the national supply chain affects the regional industry too.

The South West region has a highly successful agricultural industry, but many domestic and international factors affect food production and prices for consumers in the UK and therefore the south west region. This was evident during the world food price spike of 2008. The price spike brought an end to the long-term decline in relative price of food in the UK, and few expect it to return to past lows.

The food and drink supply chain is the UK's single largest manufacturing sector and accounts for 7% of GDP, employs 3.7M people and is worth £80Bn per year.

But although the UK has a thriving farming sector – it exported £12Bn of food and drink in 2007 – Britain is not self-sufficient in food production; it imports 40% of the total food consumed and the proportion is rising. Therefore, as a food-trading nation, Britain relies on both imports and thriving export markets to feed itself and drive economic growth.

For a region like the South West, this poses a problem for us – retailers and in particular operators in the foodservice sector (pubs, restaurants, cafes and bars) seek out least cost food products for their own customers to generate competitive advantage and to ensure profits. This economic driver can sometimes be at odds with other sustainability goals like social cohesion and environmental sustainability and market needs, wants and desires, and in particular the desire for more locally produced food.

Here in the South West, since the food scares of the 80's and 90's and in particular the Foot and Mouth outbreak of 2001, we have been encouraged as producers to re-connect with the market place as part of the localisation agenda. Taste of the West has been at the forefront of this work for 20 years and is now an industry owned and run co-operative of 800 members as representatives of the food chain from producers to wholesalers, retailers and foodservice operators.

We help producers find routes to market for their products and help the market source locally to provide for the 5 million resident population, the 20 million visitor tourist market, as well as providing additional routes into national and yes even international markets.

We have helped to build a vibrant local food economy here with a food culture which is now contributing to a visitor experience so much that tourists now look for local or regional produce when visiting. There are huge opportunities to build this market even further.

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