National Measurement Office

Government Chemist

Review 2014


“Authentication of food products requires state-of-the-art analytical methodology”

Contents

Foreword

I am pleased to introduce this review of the work of the Government Chemist function in 2014. As in prior years, the review covers the outcomes of referee cases, the research that underpinned the capability that we deployed, and the advice that was provided to UK government and industry.

As was the case in 2013, authenticity featured heavily in our referee analysis and research work and we anticipate that this will be a continuing trend. The Elliott review into the integrity and assurance of food supply networks which was initiated in the aftermath of the horse meat scandal, placed food fraud in the spotlight. Consequently we made this the principal theme of our successful biennial conference titled “Beating the cheats: Quality, safety and authenticity in the food chain” that was held at the Royal Society, London, in November. Food authenticity has both economic and social impacts; for example, where substitution involves the use of ingredients linked to known allergens. It is reassuring, therefore, that the UK and EU have responded with a number of initiatives including the formation of the UK Food Crime Unit and new allergen labelling laws.

Fraud takes many forms requiring a range of different detection solutions and molecular biology tools are becoming increasingly important in our armoury for characterising suspect goods. For this reason we have covered a number of our related research activities within this review which together demonstrate the significant and relevant developments that have been made in this field of science and in its application in areas like speciation, genetic modification and the identification of allergenic ingredients. The review also outlines other areas where we have received multiple Government Chemist referee cases, such as migration of formaldehyde from food utensils and trace chemical contamination.

Effective advice and dissemination of knowledge remain important Government Chemist activities for resolving and preventing measurement disputes, and for assisting industry in regulatory compliance. Much of our work is therefore described in more detail on our website www.gov.uk/governmentchemist which was refreshed this year and transitioned to the central Government website. If the contents of this review are of interest then I recommend that you visit the above web address for more information.

The work described herein represents the output of a programme that is managed and delivered by the Government Chemist team, funded by the National Measurement Office and overseen and advised by the Government Chemist Working Group. I would like to acknowledge each of these important inputs that together ensure that energies are effectively directed and that industry, government and the legal system can have confidence in the results of our work.

I hope that you find this review useful and informative. Your feedback on the contents is encouraged and welcomed.

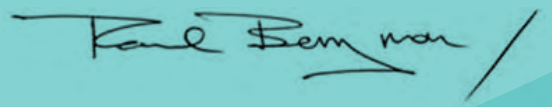
Note from the Government Chemist Working Group

I am very pleased to contribute to the 2014 Government Chemist review as Chair of the Government Chemist Working Group (GCWG).

One of the primary functions of the GCWG is in the governance and oversight of the Government Chemist programme. The Working Group comprises key stakeholders including regulatory and policy officials, representatives from industry, public analysts, port health authority officials, and academics. The GCWG meets twice a year to provide independent scrutiny of referee casework, research and advice given by the Government Chemist and also reviews the quarterly progress reports. Last year we convened a 'Decision Conference' which prioritised the capability building work of the Government Chemist to be funded under the current 2014-2017 programme, to address what we saw as the key topics upon which the Government Chemist needed to concentrate. I would like to thank the Working Group for their hard work and for the quality of advice they have provided to both the National Measurement Office and to the Government Chemist and his staff.

As this review demonstrates, the work carried out under the Government Chemist programme has built upon the impressive foundations laid in 2013 following the horse meat episode. Continuing the work on the use of DNA techniques to authenticate other species of meat and fish, whilst ensuring accuracy and traceability, will give increasing confidence to those responsible for enforcing food law and detecting adulteration, mis-labelling and many other types of food fraud.

It is clear from the topics covered in this review, that the Government Chemist and his staff display a high level of professionalism and skill to cover the broad range of referee cases, requests for advice and research projects that characterise the programme. I am sure all stakeholders will gain significant value from the review.



Professor Paul Berryman
BSc, MChemA, PhD, MBA, FRSC, CSci
Chair, Government Chemist Working Group

1 Remit

The Government Chemist role was created in 1842, to help in the protection of the public from fraud, malpractice and harm. In 1875, the laboratory was appointed as 'referee analyst', a role linked to the food and drug Acts of that year. The role continues to this day.

The Government Chemist has always used up-to-date and authoritative measurement procedures coupled with interpretative skills to act as a fair and independent arbiter to resolve disputes, to provide public protection and to contribute to effective and efficient regulatory enforcement in industrial sectors where chemical measurements are important. The need to develop measurement techniques and procedures both within our own laboratories and in collaboration with other expert organisations continues to exist. This will enable the Government Chemist to be able to respond to potential future issues as and when they arise.

The Government Chemist fulfils two functions, funded by the Department for Business, Innovation and Skills (BIS).

Statutory function

The Government Chemist has a statutory function comprising science-based duties prescribed in seven Acts of Parliament. These duties (Box 1 on page 7) cover public protection, safety, health, value for money, and consumer choice. Scientific dispute resolution is the most important part of our work; this is usually known as 'referee analysis'. We resolve disputes between regulators and businesses based upon our independent measurements and expert opinion. This is often done without recourse to legal process, which reduces the burden on public finances. Many of these cases are important and can have a significant impact on either or both parties, and so credibility of the referee rests on first-class science, which is underpinned by the assignment of our home laboratory, LGC, as the UK's designated National Measurement Institute (NMI) for chemical and bio-measurement.

Legislation covering the food, agriculture and medicinal products sectors, where the safety and protection of the consumer is of prime importance, contains equivalent provisions for the taking of official samples and subsequent analysis.

There are several routes for referral to the Government Chemist. The main route is the Food Safety (Sampling and Qualifications) (England) Regulations 2013 (and their equivalents in Scotland, Wales and Northern Ireland), which are invoked for many of the dispute resolution activities we undertake. These regulations state that all test samples are divided into three parts by an authorised officer. The enforcement authority and Food Business Operator (FBO) – 'the trader' – each receive one of these samples to perform independent analyses, while the third part of the sample is retained in case there is a dispute requiring the Government Chemist to act as referee.

In some circumstances a FBO may request a referral to the Government Chemist without having their own portion of the sample analysed (a procedure known as 'supplementary expert

opinion' – described on our website). For businesses, a successful appeal to the Government Chemist may avoid the effects of penalties prescribed under criminal law, potentially expensive compliance actions and, most seriously, loss of reputation and goodwill. Lastly, the referral sometimes comes from the court itself, with proceedings suspended pending the outcome.

When the Government Chemist's findings confirm those of the enforcement authority, the appropriate action to protect the public can, of course, proceed with increased authority. But, regardless of the outcome, the scientific outputs of the case can be disseminated to all parties and the lessons of these can hopefully be taken on board which should help reduce the possibility of recurrence. Dissemination of referee cases also takes place through scientific publications, seminars, workshops, training events and via our website, www.gov.uk/governmentchemist

► **Section 2 of this review looks at the year's completed referee cases.**

The need for referee analysis is frequently the greatest in areas where measurement breakthroughs have been made (such as speciation using DNA-based techniques), where there is widespread public or press concern, or in novel products. The Government Chemist carries out research and development (R&D) in the form of capability building projects based on horizon scanning which identifies the areas where this is most likely to occur. The outputs of these studies are disseminated publicly; in particular, stakeholders in the analytical community have access to new developments which can help them in their statutory work and can prevent referee samples needing to be taken.

► **See Section 3 for an overview of R&D activities.**

Advisory function

The Laboratory of the Government Chemist was originally founded in 1842 with the remit to detect adulteration of tobacco on behalf of HM Customs & Excise. It continued to develop after this time to become established for nearly half the 20th Century as a free-standing central department with a broad responsibility for the investigation and analysis of a wide range of samples and problems on behalf of other government departments and authorities.

The laboratory was privatised in 1996, and an agreement was signed between the Secretary of State for Trade and Industry and LGC which underpinned the continuity of the broader public functions by appointing the Government Chemist "as a source of advice for HM Government and the wider analytical community on the analytical chemistry implications on matters of policy and of standards and of regulations". This agreement continues today and serves to highlight the importance of chemical and biochemical measurements in underpinning the UK economy. With new technologies being developed and becoming more widely and routinely used, there is an even greater need for advice to be given to ensure that this happens in an appropriate manner.

The principal means of delivery of the advisory function is in the response to government calls for advice or published consultations, where there is a significant or important analytical science content. These responses provide relevant information specifically to the department, agency, European Commission Directorate-General or other body publishing the consultation, as well as to a broad range of stakeholders who have an interest in regulatory compliance and the associated measurement aspects of this. Consultation responses are published through the Government Chemist web pages. The advisory function also looks at emerging issues involving new, updated or planned regulation and related analytical measurements and addresses these by means of small targeted projects and publications, or by publication through the Government Chemist blog[1].

► **See Section 3 for more about the wider advisory function.**

Governance

The Department for Business, Innovation and Skills (BIS) funds a programme to enable delivery of statutory casework, scientific advice and any work and research necessary for the ongoing effectiveness of the Government Chemist's functions. Within BIS, responsibility for both the Government Chemist and the wider UK National Measurement System rests with the National Measurement Office (NMO).

They have put into place arrangements to ensure that the Government Chemist programme is delivered competently, and that scientific standards, impartiality, transparency and integrity are maintained. LGC has rigorous structures and procedures in place to ensure no conflicts of interest arise between work carried out under the statutory function and its commercial food analysis activities. These have been further strengthened by some structural changes to LGC's operational divisions over the past year.

The Government Chemist Working Group (GCWG) plays a key role in the governance of the Government Chemist programme, providing the necessary independent scrutiny of the programme. The GCWG also offers advice to the NMO regarding future priorities, which feeds into the programme formulation process. It meets twice a year to oversee and discuss the delivery, planning and quality of the programme, and also has oversight of the scientific standards of the programme. The GCWG is tasked by the NMO to advise on:

- The effectiveness and impact of the programme in providing an independent, expert service to resolve disputes between food control authorities and food traders on analytical results and their interpretation;
- The medium to long term Government Chemist capability building work aimed at preventing disputes arising and enabling better response to referee cases;

[1] http://governmentchemist.wordpress.com/

- The progress of the current projects in meeting technical milestones and targets; and
- The formulation and prioritisation of new projects to maintain and develop the capabilities needed to discharge the GC functions (i.e. capability building, knowledge transfer, regulatory foresight and statutory analysis).

The GCWG comprises representatives of regulatory and enforcement bodies, industry, trade associations and academia, with a broad range of backgrounds, skills and interests.

Details of the membership of the GCWG are given below:

Paul Berryman
Chair of Government Chemist Working Group

Paul is Director of Berryman Food Science Ltd, working closely with government and business, including UKTI, FERA and FSA. Paul's 30-year career includes CEO of Leatherhead Food Research, Director of SVA Ltd, Public Analyst and Trading Standards Head. He has worked with most of the top 100 global food companies.

Robbie Beattie

Robbie is appointed as Public Analyst, Agricultural Analyst and Food Examiner to Edinburgh City Council and eight other local authorities in Scotland. He leads 44 laboratory staff who test a range of samples including food, water, asbestos, consumer products and environmental samples. He also leads an Environmental Assessment team. He has had a varied career spanning a range of businesses and organisations including Royal Ordinance Factory, Scottish & Newcastle Breweries, and Glaxo Medicines Testing Laboratory.

Simon Branch

Simon joined RHM Technology as a Senior Analytical Chemist in 1990, where he progressed through a number of roles to become Head of Innovation and Improvement, before moving to the McCormick Corporation where he took responsibility for the Product and Process Development teams. In 2014, he moved to Goldenfry as Head of Innovation. During his career, Simon has sat on a number of committees including the RSC LGC advisory committee and the RSC Science and Technology Board.

Andrew Damant

Andrew leads the Scientific Methods and Laboratory Policy Team at the Food Standards Agency and is responsible for Agency policy on UK national reference (FSA) laboratories and official control laboratories. Andrew is an official UK delegate on numerous international committees and also acts as advisor to various UK committees.

Kirsty Dawes

Kirsty Dawes, is an imported food specialist, working for Suffolk Coastal Port Health Authority, based at the Port of Felixstowe. Kirsty is an Environmental Health Practitioner with a BSc in Environmental Health, and one of the few non-chemists represented on the group. A large proportion of the referee samples considered by the Government Chemist originate as a result of samples taken at the point of import and Kirsty is able to contribute knowledge of the import and sampling process to the groups work.

Lucy Foster

Lucy began her career as a government scientist at the Ministry of Agriculture, Fisheries and Food in 1998. She joined the Food Standards Agency in 2000 before moving to the Department for Food and Rural Affairs (DEFRA) in 2009 to manage Defra's food science evidence programmes. Lucy has considerable experience in food safety from a science and a policy perspective, including microbiological foodborne disease, food hygiene, food additives and food compositional and labelling standards.

Jonathan Griffin

Jonathan began his career as a Graduate Scientist at Kent County Council, where he carried out classical and instrumental analysis of foods, agricultural samples, water and consumer goods. He completed the Mastership of Chemical Analysis (MChemA) in 2002 and became a Public Analyst. He continues to work as Public Analyst and Technical Manager for Kent Scientific Services.

Martin Hall

Martin is the Director of Science at Campden BRI and has overall responsibility for the departments of Chemistry and Biochemistry, Microbiology, Consumer & Sensory Science and Statistics. Martin has 40 years' experience of a wide range of food related subjects with specific interests in food safety and quality, authenticity and analytical techniques.

Declan Naughton

Declan joined the Inflammation Research Group at Barts and The London School of Medicine and Dentistry, where he spent 10 years before accepting posts at Bath University and the University of Brighton. He is currently Professor of Biomolecular Sciences at Kingston University London. His research interests span food safety, nutrition, natural products, performance enhancing drugs, inflammation, drug discovery, and endocrinology.

Linda Plested

Linda started her career in food science working for the Milk Marketing Board, before joining the Watney Mann and Truman Brewers network where she undertook analytical and project work. In 2001, she became a Trading Standards Officer for Surrey County Council, where she continues to work today. Linda represents the Trading Standards profession on the working group.

Roger Wood

Roger is an experienced food analysis specialist, who recently retired from the UK's Food Standards Agency He holds the Mastership in Chemical Analysis, (MChemA), the statutory qualification required to practice as a Public Analyst. He has represented the UK at numerous EU methods of analysis and sampling Working Groups in the food and feed sectors over the past 35 years.

The current Government Chemist programme

The current Government Chemist programme, covering 2014-2017, commenced in April 2014. The programme reflects the prioritisation exercise carried out by the GCWG, and is similar in structure and themes to the 2011-2014 programme:

- Intelligence gathering: horizon-scanning projects on the scientific implications of policy development, emerging legislation, changes to existing legislation and enforcement trends;
- Capability building: innovative and relevant R&D which aims to reflect potential needs for future casework under the Government Chemist's statutory role;
- Statutory activities: work carried out in relation to individual cases that are referred to the Government Chemist under his statutory function as defined in Acts of Parliament;
- Knowledge transfer: improved dissemination of regulatory and analytical developments to a wide range of stakeholders, to stimulate improvement of standards of measurements, the understanding of the regulatory environment and to help industry to innovate concerning new products and processes.

This is the first Annual Review of the current GC programme, which started in April 2014 and runs for three years. This is a brief summary of the make-up of the new programme. The main aim of the programme remains the statutory referee analyst function, which requires no further introduction, but there are a number of other activities and projects that are also part of the programme which support and enable the Government Chemist to discharge this function properly and effectively.

An important aspect of the programme is to ensure we are well equipped and prepared to deal with future referee cases. To this end, the programme contains a series of laboratory-based projects that build and extend our technical capabilities. These were developed through stakeholder consultation and prioritised by the GCWG (the independent expert panel that review the programme) and thus reflect the future direction of measurement testing in the food industry. These include projects to improve the detection of food allergens (using DNA, ELISA and mass spectrometry technologies), to improve authenticity testing of meat and fish and the detection of GMO foods (using DNA-based methods), and, for mycotoxin detection (using mass spectrometry approaches).

Other laboratory-based components of the programme ensure we maintain high standards of quality and performance in our established capabilities through participation in proficiency testing schemes. In addition, we also deliver some small scale laboratory studies to apply our technical expertise to address measurement challenges faced through the introduction of new legislation for the food and chemical industries (e.g. trace detection of pollutants under the Water Framework Directive).

The final element of the programme ensures our relevance and impact to UK stakeholders. Here, a broad range of horizon scanning and stakeholder engagement activities keep us abreast of regulatory and technology developments, whilst importantly, we ensure programme outputs and advice are clearly communicated to the UK scientific audience and the government (e.g. via stakeholder events such as the GC Conference, joint Defra/FSA technical workshops, maintenance of and publication of GC articles on the GC website).

People

LGC staff who directly support the Government Chemist function have clearly and independently defined roles (Figure 1). Within this framework, there are particular requirements for the management of statutory casework:

- Nominated officers, one of whom holds the requisite statutory qualification[2], have overall responsibility for case supervision. They prepare and sign Government Chemist certificates of analysis;
- Only the Government Chemist or Deputy, once satisfied that the case has been properly completed, may countersign.

The members of staff carrying out work under the Government Chemist's statutory function must continually demonstrate their competence through participation in an extensive variety of appropriate proficiency testing schemes and collaborative studies. The diverse nature of LGC's scientific activities therefore leads to a wide range of skills and specialisms being available in-house. Many of the staff involved in delivering the programme have also carried out research and development work, which often involves programmes with international collaboration, which gives them the capability to contribute positively and efficiently to their work.

[2] All work is overseen by Michael Walker, a nominated officer holding the statutory MChemA qualification

Collaboration

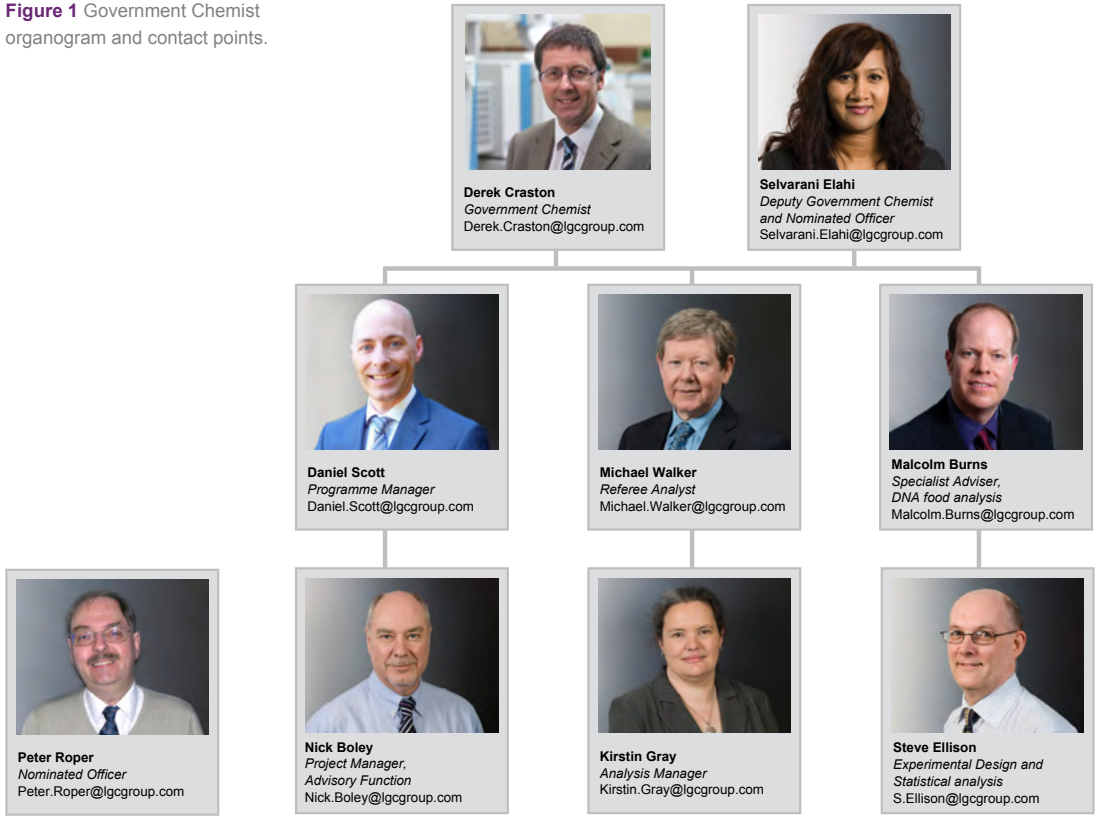
The range of potential areas of work which fall under our remit is very broad. Challenges can arise from unexpected sources, despite our horizon scanning activities. Consequently, some of these challenges may lie outside our current spheres of expertise, or where the specific skills or equipment necessary are not readily available in-house.

The need can therefore arise to collaborate with stakeholders, both existing and new, to appropriately discharge our function, whilst maintaining control over the scientific direction and integrity of the work. This enables our capability building research and development work to be responsive and involve appropriate expertise within the scientific measurement community. Therefore we can continue to benefit public health, safety and well-being, as well as the wider scientific community, including those UK manufacturing industries which depend on reliable and accurate analytical measurement, and how they interact with regulation.

If you would like to get involved with any aspect of our work, or for more information on our work, please contact us at Government.Chemist@lgcgroup.com or go to the website www.gov.uk/governmentchemist

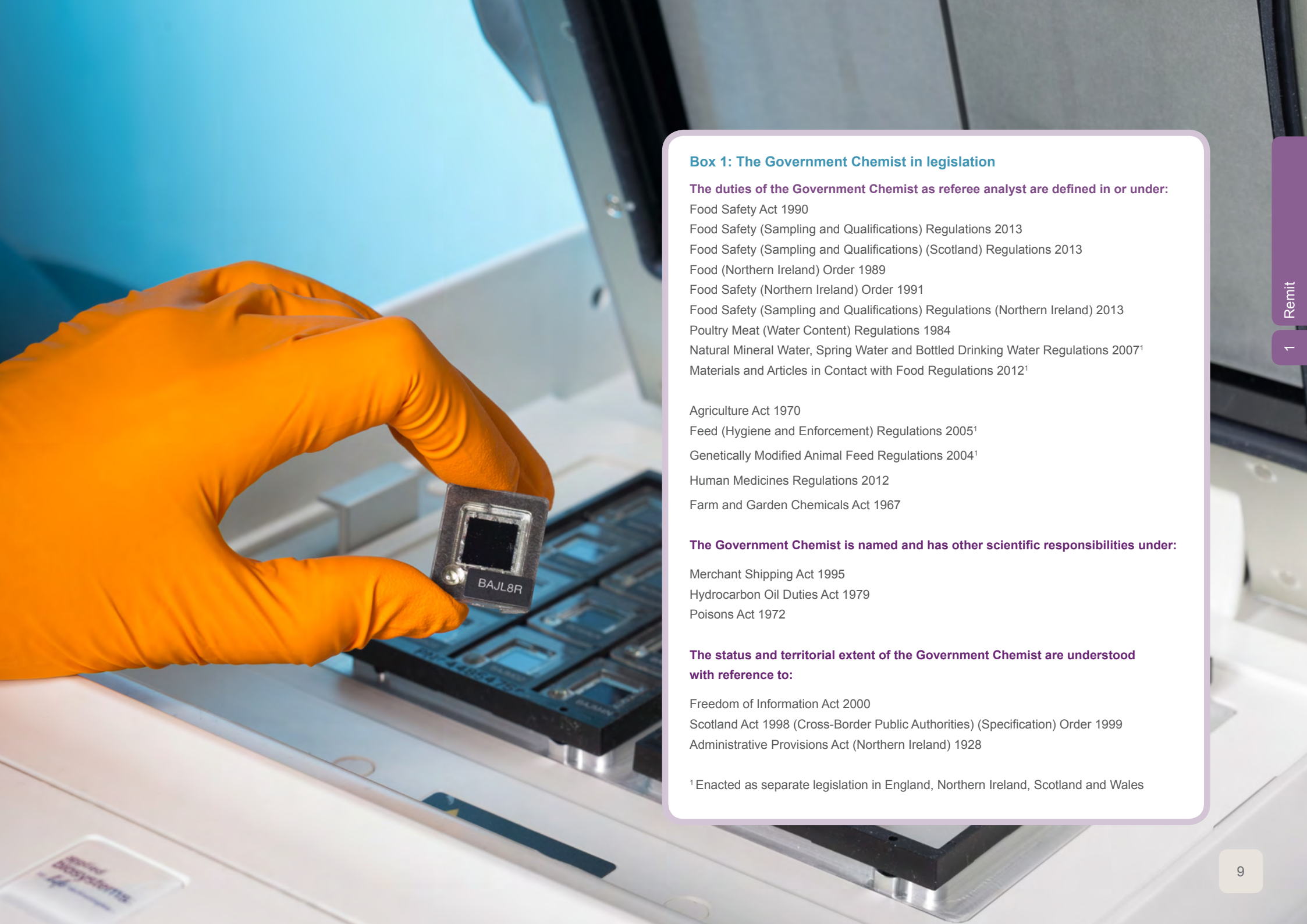
We are very sad to report the death this year of Peter Roper. Peter had worked at LGC for over 40 years and had provided advice to the Government Chemist over several years in his role as a National Officer covering alcoholic drinks.

Figure 1 Government Chemist organogram and contact points.



National Measurement Office

[2] All work is overseen by Michael Walker, a nominated officer holding the statutory MChemA qualification



Box 1: The Government Chemist in legislation

The duties of the Government Chemist as referee analyst are defined in or under:

Food Safety Act 1990
Food Safety (Sampling and Qualifications) Regulations 2013
Food Safety (Sampling and Qualifications) (Scotland) Regulations 2013
Food (Northern Ireland) Order 1989
Food Safety (Northern Ireland) Order 1991
Food Safety (Sampling and Qualifications) Regulations (Northern Ireland) 2013
Poultry Meat (Water Content) Regulations 1984
Natural Mineral Water, Spring Water and Bottled Drinking Water Regulations 2007[1]
Materials and Articles in Contact with Food Regulations 2012[1]

Agriculture Act 1970
Feed (Hygiene and Enforcement) Regulations 2005[1]
Genetically Modified Animal Feed Regulations 2004[1]
Human Medicines Regulations 2012
Farm and Garden Chemicals Act 1967

The Government Chemist is named and has other scientific responsibilities under:

Merchant Shipping Act 1995
Hydrocarbon Oil Duties Act 1979
Poisons Act 1972

The status and territorial extent of the Government Chemist are understood with reference to:

Freedom of Information Act 2000
Scotland Act 1998 (Cross-Border Public Authorities) (Specification) Order 1999
Administrative Provisions Act (Northern Ireland) 1928

[1] Enacted as separate legislation in England, Northern Ireland, Scotland and Wales

2 Science underpinning sound dispute resolution

Referee casework arises most frequently under the Food Safety Act 1990 or the Agriculture Act 1970.

Formal samples taken under statutory enforcement provisions are divided into parts for analysis on behalf of the authorities, the food and feed business operator (FBO) and, when required, the referee. During 2014, 16 cases were referred to the Government Chemist, all in connection with the Food Safety Act. Further information about some of these cases is presented later in this section.

The Referee Function

A wide variety of problems were referred to us in 2014, encompassing additives, animal species identification, food contact materials, GMOs, food labelling, mycotoxins, pesticides and veterinary residues. Expertise in both analytical chemistry and molecular biology were required. There were 16 cases in 2014 as well as one Supplementary Expert Opinion. Table 1 provides an overview.

Table 1 Overview of Referee Cases in 2014

Origin			Basis		
Inland Authority	4	23.5 %	Dispute	14	82.4 %
Port Health Authority	13	76.5 %	SEO*	3	17.6 %

SEO – Supplementary Expert Opinion, pursuant to Article 11(5) of Regulation 882/2004 *on official controls*

Referee casework is a demand led service which has been at the core of the Government Chemist's function since 1875 and demand remains at the heightened levels seen in 2013. – see Figure 2.

In guaranteeing fair scientific treatment for all by authoritative adjudication on disputes, we underpin public confidence in food and feed official control system. We maintain the even-handed credibility of this referee role by stringent governance of the function and painstaking analytical rigour. Our aim is to safeguard consumers, regulators, the agrifood sector and the courts from unwitting errors in measurement science.

Figure 2 Referee Cases by year

Referee casework can arise under both the Food Safety Act 1990 and the Agriculture Act 1970, although no agriculture cases were referred in 2014. Formal samples taken under statutory enforcement provisions are divided into parts for analysis on behalf of the authorities, the food or feed business operator (FBO) and, when required, the referee.

Analytical results must be interpreted in increasingly complex scientific legal and policy contexts, and in an increasingly global supply chain. When a referral is received we begin with a case meeting to examine the problems associated with the case and instigate a literature review in the area if it is new to us. Our default analytical strategy is multi-replicate analyses on multiple days. The extent of replication together with analysis of certified reference materials, where available, and of blanks and spiked blanks provide an exceptionally high level of analytical confidence. All significant analytical steps are witnessed by a second scientist and the results are evaluated against prescribed quality control criteria. The entire dataset is independently evaluated by professional statisticians for bias and outlying results and to yield a case specific measurement uncertainty if required. A certificate is drafted and reviewed by a qualified person and finally the case file is brought to the Government Chemist for peer review. If all steps are satisfactory, the Government Chemist will allow the findings to be released usually in the form of a certificate. Along with the high-end equipment deployed, these measures are aimed to give the food business owner, the courts and regulators the necessary assurance that the appellate function is discharged to the highest possible professional standards.

Food additives

It is some years since we have had a referee case on a food additive. A referral in 2014 concerned the preservative sulphur dioxide in dried apricots, the first time this analyte has been referred for many years despite a relatively high number of official analyses for sulphites. Food additives, including preservatives, are strictly regulated in European law. No compounds are permitted for use in food as additives unless they are assessed independently as safe, there is a technological reason for their use and their use does not mislead consumers. In many cases the maximum permitted concentrations are prescribed in law. Despite this protection, consumer concern about food additives persists. An FSA survey in 2014 found that food additives remained in the top three food safety issues of total (i.e. spontaneous plus prompted) concern for respondents, along with food hygiene when eating out, and food poisoning[3]. Sulphites are useful additives; they inhibit both enzymatic and non-enzymatic browning, have antimicrobial activity, dough conditioning properties and bleaching effects and hence are widely used. There is some concern that acceptable daily intakes of sulphites, set to avoid gastric irritation, are exceeded in some populations[4]. The presence of sulphites in food must be highlighted owing to sulphite sensitivity in some individuals that is characterised by severe bronchospasm, which can occur within minutes after ingestion of sulphite-containing foods. Hence sulphites must not be used in foods where they are not permitted and their concentrations limited to prescribed maxima in food in which they are allowed. The maximum permitted level in dried apricots is 2000 mg/kg, expressed as sulphur dioxide, is relatively high compared to most foods.[5,6]

In this case the Public Analyst reported a concentration of 2382 mg/kg, an excess concentration when measurement uncertainty was taken into account, whereas the laboratory acting for the FBO reported 1719 mg/kg. We applied the well-known Monier-Williams method to the analysis of the sample, figure 3, a wholly classical volumetric approach standardised by both CEN (the European Committee for Standardisation) and AOAC (the Association of Official Analytical Chemists). An aliquot of the homogenised sample is heated under acid reflux to release free and a reproducible portion of bound sulphites as sulphur dioxide, which is then transferred by an oxygen-free nitrogen purge into a solution of hydrogen peroxide for oxidation to sulphuric acid. The generated sulphuric acid is titrated with 0.01M sodium hydroxide solution.

Two replicates of the laboratory sample were analysed on each of four days alongside spiked samples and appropriate reference materials. Our result of 2110 ± 180 mg/kg[7] confirmed the Public Analyst's findings. However, since the lower bound of the confidence interval (1930 mg/kg) lay below the limit of 2000 mg/kg the sample was not non-compliant beyond reasonable doubt.

Figure 3 Determination of sulphites as sulphur dioxide by the Monier-Williams method

[3] Food Standards Agency, 2014, Biannual Public Attitudes Tracker Wave 8, May 2014, Social Science Research Unit, July 2014, https://www.food.gov.uk/sites/default/files/multimedia/pdfs/science-research/tracker-may2014.pdf (accessed 24.01.2015)

[4] World Health Organisation, WHO, 2009, Safety evaluation of certain food additives / prepared by the sixty-ninth meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA). (WHO food additives series, 60)

[5] Commission Regulation (EU) No 1129/2011 of 11 November 2011 amending Annex II to Regulation (EC) No 1333/2008 of the European Parliament and of the Council by establishing a Union list of food additives

[6] European Food Safety Authority, EFSA, 2004, Opinion of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission relating to the evaluation of allergenic foods for labelling purposes, The EFSA Journal 32, 1-197

[7] Expanded measurement uncertainty as a 95 % confidence interval.

Animal speciation

Following the horse meat scandal[8] of 2013, with its attendant focus on the determination of the species of animal present in processed food by PCR DNA methods, salience of these issues remained high and two cases were dealt with. One stemmed directly from the horse meat episode and was referred just before proceedings commenced. The prosecution was as a result of a Public Analyst's finding of 46 % equine DNA in a sample of Bulgarian pork sausage. The food business owner approached the Government Chemist for a second opinion but was unable to offer any evidence to contradict the Public Analyst's findings. The Food Safety (Sampling and Qualifications) Regulations 2013 that govern referrals no longer require the agreement of the authorised officer or prosecutor to such a request. However, to safeguard the public funds expended in a referee case the Government Chemist usually asks for some evidence that the official analyst may be in error. Three options were offered to the food business:

- Invite the court to refer the retained portion
- Offer SEO at full cost
- If the business could show it made an effort to have their portion analysed the Government Chemist would endeavour to assist.

In the event the business had documentary evidence that they had sent their portion of the formal sample to a laboratory for analysis but it had not arrived. We therefore accepted the retained portion from the Trading Standards department sample, homogenised it and forwarded half directly to a laboratory of the food business's choice for analysis on their behalf at their own expense. Had this resulted in findings that contradicted those of the Public Analyst we would then have initiated a referee analysis in the usual way. However the Public Analyst's results were confirmed and the business put in a guilty plea. This was the first prosecution to arise from the horse meat episode and we were pleased that our flexibility in dealing with the matter had brought it to a swift conclusion.

Following the shortcomings in molecular biological approaches to speciation identified in our 2013 annual report, we carried out several further studies. One aimed to evaluate the limits of detection (LOD), of three selected methods used by Public Analysts as part of the 2013 UK horse meat survey. The three methods evaluated were a PCR-Capillary Electrophoresis approach, a PrimerDesign method and a Neogen BioKits method. Results showed that all three methods were capable of reaching an LOD of less than 0.1 % w/w raw horse meat in a raw beef (meat) background if quality procedures and good laboratory practice for molecular biology methods were adhered to[11]. Further discussion of this topic can be found in the article on meat and fish authenticity testing in Section 3 of this review.

The second speciation case involved the identification and labelling of squid. Squid are cephalopods, members of the phylum *Mollusca*, class *Cephalopoda*, subclass *Coleoidea*, along with octopus and cuttlefish[9]. There are many species of squid, and this case concerned retail packs of squid labelled " ... frozen New Zealand Squid". On the back label of the item the ingredients stated "squid" and further information "Produced in New Zealand and packed in the UK from arrow squid caught in the South West Pacific Ocean...". Arrow squid is the commercial designation for squid of the species *Nototodarus gouldi* and *Nototodarus sloanii*. The Public Analyst certified that DNA extracted from the sample was consistent with that of *Illex argentinus* or the Argentine short fin squid whereas a laboratory acting for the FBO reported that their portion contained DNA of *Nototodarus gouldi* and *Nototodarus sloanii* consistent with the label information.

[8] Horse meat in beef products, species substitution, 2013, Michael J. Walker, Malcolm Burns and D Thorburn Burns, 2013, J Assoc Public Analysts (Online) 41, 67 – 106

[9] And Belemnites which are known only in the fossil record

Our approach to the possible identification of the sample took a number of steps as follows.

- We reviewed the recent molecular biology literature for cephalopoda and identified relevant publically accessible sequence database resources and retrieved relevant DNA sequence information;
- We aligned the DNA sequences, obtained consensus sequence construction and evaluated these for species discrimination;
- Primer design, extraction of DNA, amplification of DNA and sequence read analysis followed.

Based on the limited DNA sequence data available for *Illex* and *Nototodarus*, and the results generated for the sequencing of a 330 bp amplicon derived from the mitochondrial Cytochrome Oxidase I (COI) gene, our analysis led us to conclude that the sample exhibited a 100% similarity with *Illex argentinus*, and a 99 % similarity with *Nototodarus* sloanii. Hence no valid differentiation could be drawn between the results proffered by each of the laboratories previously involved in the matter. In effect they were both correct as far as the information currently known to science is concerned. Taxonomic difficulties in the *cephalopoda* are well recognised[10], and coupled with this there are only a limited number of relevant individual specimens of *Illex* and *Nototodarus* that have been sequenced. This emphasises the need for authenticated reference material for cephalopods and more validated sequence information in curated databases.

Food contact materials

Food Contact Materials, FCM, are defined as containers, packaging, cutlery, dishes, and anything that comes into contact with food or water, that can transfer chemical components into food. Materials such as plastics, paper and board, metals, ceramics are commonly used for the manufacturing of food packaging, but also kitchenware, cutlery and food processing machinery. To protect public safety and consumer confidence, FCM must not transfer their components into the foods in unacceptable quantities with regard to safety or organoleptic properties. Limits are set in law on the transfer (migration) of specific compounds and there are also generic limits for non-specific, or 'overall' migration.

During 2014 three FCM cases were referred, all involving imported melamine ware reported to transfer excess formaldehyde on testing by Public Analysts.

The thermosetting plastic melamine is used to manufacture a diversity of inexpensive food contact articles intended for repeated use. Melamine is a polycondensation product of the monomers formaldehyde and melamine and residues of both may remain in the finished product. Thus both compounds are on the EU monomer positive list with specific migration limits.[12] Formaldehyde, HCHO, is an interesting example of a compound that occurs in food both from natural and man-made sources. Its toxicology is complex; it is known to be capable of sensitising some people to allergic contact dermatitis and there is evidence that it is a carcinogen.[13,14]

[10] A. Louise Allcock, A. Lindgren & J. M. Strugnell (2014): The contribution of molecular data to our understanding of cephalopod evolution and systematics: a review, Journal of Natural History, DOI: 10.1080/00222933.2013.825342

[11] Eloise Busby and Malcolm Burns, 2014, Method Verification of the LOD Associated with PCR Approaches for the Detection of Horse Meat, J Assoc Public Analysts (Online), 42, 1 - 17

[12] K. H. Lund, J. H. Petersen, 2006, Migration of formaldehyde and melamine monomers from kitchen- and tableware made of melamine plastic, Food Additives and Contaminants, 23, 948-955

[13] Lois Lehman-McKeeman, 2010, Paracelsus and Formaldehyde 2010: The Dose to the Target Organ Makes the Poison, Toxicol. Sci. 116, 361-363

[14] Hermann M. Bolt, Peter Morfeld, 2012, New results on formaldehyde: the 2nd International Formaldehyde Science Conference (Madrid, 19–20 April 2012), Arch Toxicol. 87, 217–222

Regulation (EU) No 284/2011 lays down conditions and procedures for the import of polyamide and melamine plastic kitchenware originating in or consigned from the People's Republic of China and Hong Kong Special Administrative Region, China. The obligations of the Government Chemist to act in relation to FCM derives from successive national measures[15] on Materials and Articles in Contact with Food implementing and enforcing a group of European Directives and Regulations designed to protect consumers' health and remove technical barriers to trade[16]. Article 11 and Annex I of Commission Regulation (EU) 10/2011 limit the transfer of formaldehyde from FCM to a maximum of 15 milligrams of formaldehyde per kilogram of food, mg/kg.

The analysis in each case was informed by guidance issued by the European Reference Laboratory for Food Contact Materials. Formaldehyde migration was determined by exposure of the plastic material at 70° C for two hours to 3 % v/v aqueous acetic acid food simulant to mimic the worst case scenario in actual use. The analytical finish applied two well known reactions, one with chromotropic acid and the other with pentane-2,4-dione (acetylacetone) stoichiometrically to produce coloured reaction products for the spectrometric determination of migrated formaldehyde[17]. Since the test items were intended for repeated use each item was exposed to fresh food simulant in three consecutive tests with formaldehyde concentrations reported from the third (final) exposure of each test specimen. In each instance, three replicates were analysed alongside exposed food simulant spiked with formaldehyde and blank (unexposed) simulant. As is usual a case specific measurement uncertainty was derived and applied in appraisal of the results.

Figures 4 to 6 illustrate the results obtained by the Government Chemist and the other laboratories involved in the three referee cases on FCM dealt with in 2014. The data represent (for the GC and Public Analyst results) the mean minus the expanded measurement uncertainty, i.e. 'not less than' figures. Note the data do not represent comparative results on the same items but on successively different items as available and chosen at random. We upheld the Public Analysts' findings that the consignments were non-compliant, in the first case because formaldehyde migration from the items exceeded the limit and in the two remaining cases because some items exceeded the limit and overall the samples failed to demonstrate compliance with Regulation 2023/2006 of 22 December 2006 on good manufacturing practice for FCM by way of lack of control to ensure conformity with the maximum of 15 mg/kg[18]. The data generally exhibit a great deal of dispersion reflecting non-uniformity of composition rather than analytical variance.

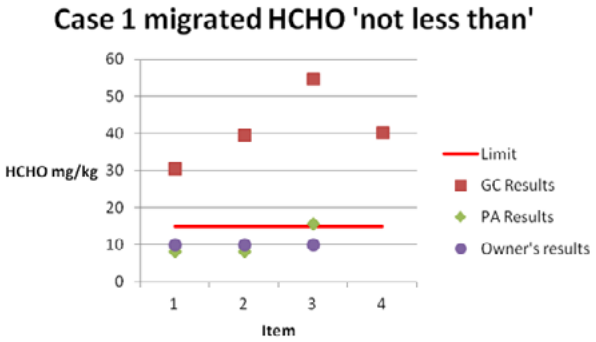


Figure 4 Data from case 1 migration of formaldehyde (HCHO) from melamine ware

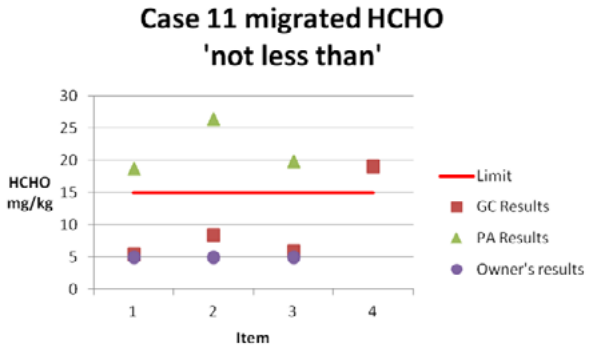


Figure 5 Data from case 11 migration of formaldehyde (HCHO) from melamine ware

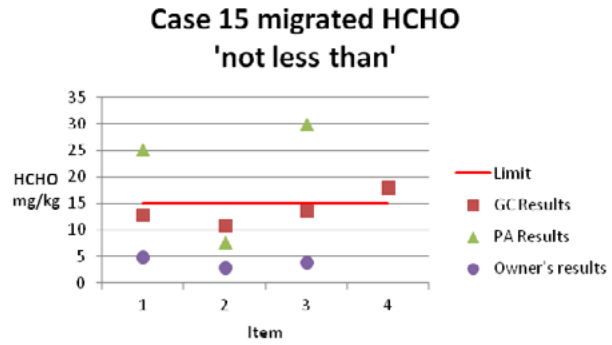


Figure 6 Data from case 15 migration of formaldehyde (HCHO) from melamine ware

[15] The Materials and Articles in Contact with Food (England) Regulations 2012, No. 2619, the Materials and Articles in Contact with Food (Scotland) Regulations 2012, No. 318, the Materials and Articles in Contact with Food (Wales) Regulations 2012, No. 2705 (W. 291) and the Materials and Articles in Contact with Food Regulations (Northern Ireland) 2012, No. 384

[16] European Commission, Food Contact Materials, http://ec.europa.eu/food/food/chemicalsafety/foodcontact/index_en.htm accessed 25.01.15

[17] According to CEN/TS 13130-23, Materials and articles in contact with foodstuffs – Plastics substances subject to limitation – Part 23: Determination of formaldehyde and hexamethylenetetramine in food simulants.

[18] Commission Regulation (EC) No 2023/2006 of 22 December 2006 on good manufacturing practice, GMP, for materials and articles intended to come into contact with food requires business operators to establish GMP listed in Annex I to Regulation (EC) No 1935/2004 to ensure that materials and articles are consistently produced and controlled to ensure conformity with the rules applicable to them. The requirements are to be applied proportionately to avoid undue burdens for small businesses and allow the trader to produce appropriate paper or electronic documentary records to the competent authorities at their request.

Genetically Modified Organisms, GMOs

EU law[19] prohibits the placing on the market of GM food unless it is officially authorised, after demonstration that it does not have adverse effects on health or the environment and that it does not mislead the consumer. In addition, the GM food must not differ from the food it is intended to replace to such an extent that its normal consumption would be nutritionally disadvantageous. Similar provisions apply to GM animal feed.

There are no genetically modified rice products authorised in the European Union[20], but from 2006 onwards some rice products originating in or consigned from China were discovered to be contaminated with the unauthorised genetically modified rice Bt 63. The Chinese authorities took steps to control the presence of unauthorised GM rice, however unauthorised GM rice including other varieties continued to be found in rice imported into the EU. As a consequence, the EU requires rice imports from China to be accompanied by an analytical report demonstrating the absence of GM rice. From December 2011 all rice imports from China have been subject to inspection, sampling and analysis and in 2012 we began to see referrals of disputed results from such official sampling and analysis. There were no GMO cases referred in 2013, however 2014 saw another sample referred to us. Owing to lack of details of the full DNA sequence information of genetically modified rice varieties available in China, a screening approach is adopted for certain generic genetic elements. GM plants are generally produced by inserting a transgenic sequence that encodes for a desired trait into the host genome. The trait sequence is typically bounded by regulatory promoter and terminator sequences, some of the most common being the 35S promoter derived from Cauliflower Mosaic Virus (P35S) and the nopaline synthase terminator (TNOS) derived from *Agrobacterium tumefaciens*. Thus P35S and TNOS are useful screening targets together with a prevalent insect resistance trait sequence representing genes encoding for the genetically engineered *Bacillus thuringiensis* endotoxins CrylAb/Ac, globular protein molecules, which accumulate in crystalline form.

The most common chemistries used to produce a signal (Cycle Threshold, (in C_t)) downstream of PCR are the use of a specific fluorescent probe (Taqman) or DNA binding (intercalating) fluorescent dyes (e.g. SYBR Green I). In SYBR® Green chemistry the fluorescent dye binds to the minor groove of DNA, but may also bind to nonspecific PCR products and primer dimers. Thus the C_t alone is insufficient to identify positively the presence of the genetic element sought. To address this, the first derivative of fluorescence against temperature is plotted to pinpoint the DNA fragment melting point (dissociation of the double stranded DNA, the melting curve). Based on this melting temperature,T_m, a direct property of the DNA fragment nucleotide content, it is possible to distinguish nonspecific fragments from specific PCR products [21]. In the SYBR Green® assay the target is considered detected, according to EU-RL GMFF guidance when *paired duplicate* extractions both give a signal for C_t and T_m; that is, a detectable amplification (Ct) must be accompanied by a melting temperature (T_m) that is within 1.5°C of the T_m of the positive controls.

In general multi-day, multiple replicates of the samples are analysed by a specialist team of molecular biologists. Positive and negative controls are assayed (certified reference materials for Bt11, Mon810, LLRICE62; no-template aqueous controls; wild-type rice), and real-time PCR assays are carried out for a rice taxon-specific phospholipase D (PLD)[22]. Two real-time PCR instruments from separate manufacturers are deployed and interpretation of results is based both on instrument default automatic threshold settings and expert judgement of amplification curves and melting temperature plots. Where required, and applicable, confirmatory procedures are applied for example based on those of the GMO National Reference Laboratories of Germany [23]. In 2013 we developed and published an in-house plasmid control for CaMV to aid detection of GM Rice Lines [24].

[19] Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed

[20] Commission Decision 2011/884/EU Recital 8.

[21] Sylvia R. M. Broeders, Sigrid C. J. De Keersmaecker, and Nancy H. C. Roosens, 2012, How to Deal with the Upcoming Challenges in GMO Detection in Food and Feed, Journal of Biomedicine and Biotechnology, Article ID 402418

[22] Mbongolo Mbella et al., 2011, SYBR®Green qPCR methods for detection of endogenous reference genes in commodity crops: a step ahead in combinatory screening for Genetically Modified Crops in food and feed products, Eur. Food Res. Technol. 232:485-496

[23] Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, Guideline detection of genetically modified rice 26 March 2012

[24] Malcolm Burns, Gavin Nixon, Michael Walker, Eloise Busby, 2013, Development of an in-house Plasmid Control for Cauliflower Mosaic Virus (CaMV) for the Detection of Genetically Modified (GM) Chinese Rice Lines, J Assoc Public Analysts (Online), 41, 45-52

In the 2014 case the Public Analyst detected the 35S promoter sequence and the NOS terminator sequence, whereas a laboratory acting for the food business owner reported none of the screening targets were detected. The Government Chemist applied the SYBR® Green assay for the rice taxon-specific phospholipase D (PLD) with strong detection of the PLD gene as evidenced by early C_t values and easily identifiable T_m peaks. SYBR® Green assays for the 35S promoter derived from Cauliflower Mosaic Virus, nopaline synthase terminator (T-NOS) derived from Agrobacterium tumefaciens and the genetically engineered CryIAb/Ac were applied to multiple individual extractions from the referee sample. In all cases this resulted in no detection of the respective 35S and T-NOS target elements at all. Paired positive C_t signals for CryIAb/Ac were repeatedly detected however were never accompanied by appropriate melting temperatures (T_m). Thus we reported that no generic genetic elements were detected.

Each of the seven GM cases we have dealt with in 2012 and 2014 threw up issues of interpretation, and dialogue continued over the period with importers and the laboratories involved. GM rice detection methodology is acknowledged to be analytically and interpretively problematic.

Hence, with the support of the FSA the Government Chemist team, led by Dr Malcolm Burns, head of the UK National Reference Laboratory for GMOs, hosted an interactive workshop on these issues in June 2014. European Union Reference Laboratory guidance was discussed with an overview of the recently revised parts of the guidance. PCR positive control material recently provided to Public Analysts by LGC for use when analysing for Chinese GM rice was explained. During the afternoon session delegates analysed example data sets, many arising from referee cases, and discussed and agreed issues on the interpretation of results. Each Public Analyst laboratory provided a short presentation emphasising its experiences with GMO analysis and highlighted issues that they faced, which were debated as part of round table discussions. The discussions appeared to achieve consensus on technical issues surrounding results interpretation and the need for further standardisation, which will be fed back to the EU Reference Laboratory. This was a good example of synergy between the Government Chemist and the National Reference Laboratory applied to iron out measurement difficulties for the benefit of all stakeholders.

More details of this workshop are given on page 25.

Pesticides residues

All foodstuffs intended for human or animal consumption in the EU must conform to maximum residue levels (MRLs) for pesticides in order to protect animal and human health.[25] MRLs are a complex issue but in general are recommended by European Food Safety Authority (EFSA) based on a risk assessment and adopted in law by the Commission. Where a MRL has not been specifically set a 'default' MRL of 0.01 mg kg is applied. Article 18 of Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin[26] prohibits products being placed on the market as food or feed if they contain a pesticide residue exceeding the prescribed MRL. No referee casework on pesticides residues took place since 2000 prior to 2013 when one case was referred. In 2014 we dealt with three cases. Table 2 gives an overview of the cases. As with all referee cases multiple replicates of the homogenised samples were analysed on each of at least three days.

In the first case in 2014, the retained portion delivered to the Government Chemist did not exhibit sufficient proof of a proper chain of custody owing to the inexperience of the contract laboratory handling the sample. In addition, both official and defence results were well above the MRL and the parties were advised that a referee analysis was unlikely to alter the position. As a result of this it was accepted by the food business that the consignment was non-compliant.

In the second case the Public Analyst's results were upheld and the consignment was confirmed to be non-compliant. The food business owner's laboratory mistakenly assumed the MRL for cypermethrin to be 0.07 mg/kg. The GC analysis included prewetting, ethyl acetate extraction, solid phase clean-up and gas chromatography tandem mass spectrometry (GC-MS/MS). Deuterated analogues of each compound were included in each analytical procedure as internal standards. Cypermethrin was determined as the sum of its isomers. Recovery experiments were carried out and deemed satisfactory however as is the norm for the determination of pesticides these data were not used to recovery correct the results.

In the third case our analysis was based on a QuEChERS-type [27] extraction. After addition of water to a homogenised sample, transfer of hexachlorobenzene into an acetonitrile layer was aided by the addition of inorganic salts followed by gas chromatography mass spectrometry (GC-MS).[28] Quantitation was performed by standard addition including with isotopically labelled hexachlorobenzene. The Public Analyst's results were upheld.

[25] Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC

[26] Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin, consolidated version of 02.02.2014 available at http://eur-lex.europa.eu/Notice.do?val=400559:cs&lang=en&list=400559:cs,&pos=1&page=1&nbl=1&pgs=10&hwords=

[27] QuEChERS stands for Quick, Easy, Cheap, Effective, Rugged, Safe an analytical approach introduced in 2003 that vastly simplifies the analysis of multiple pesticide residues in fruit, vegetables, cereals and processed products thereof. Anastassiades M, Lehotay SJ, Stajnbaher D and Schenck FJ, 2003, Fast and easy multiresidue method employing acetonitrile extraction/partitioning and dispersive solid-phase extraction for the determination of pesticide residues in produce, JAOAC Int., 86, 412-31, see for example http://quechers.cvua-stuttgart.de/index.php?nav1o=1&nav2o=0&nav3o=0 (accessed 25.01.2015)

Table 2 Overview of Pesticides Referee Cases in 2014

Case	Matrix	Pesticide	MRL mg/kg	PA mg/kg	FBO mg/kg	GC mg/kg
2011/14-42	Green beans	Diafenthiuron	0.01	0.10	0.02	No GC analysis, poor sample provenance and extant results well above MRL
2011/14-43	Oloyin beans	Dichlorvos Cypermethrin	0.01 0.05	0.28 0.18	ND 0.079	Not less than 0.19 Not less than 0.05
2014/17-12	Organic Green tea		0.02	0.049	0.036	Not less than 0.041

MRL – Maximum Residue Level
PA, FBO – Results obtained by Public Analyst and Food Business Operator respectively, a 50 % uncertainty must be subtracted before appraisal against the MRL
GC – Results obtained by the Government Chemist, a case specific measurement uncertainty was obtained and subtracted to yield a 'not less than' figure

Veterinary drug residues

Food-producing animals may be treated with veterinary medicines to prevent or cure disease. These medicines may leave residues in the food from treated animals but should not harm the consumer and there are European wide rules such that only safe veterinary medicinal products are authorised for use. Where such products are permitted in food producing animals maximum residue levels (MRLs) are set, and monitoring takes place to detect the illegal use or misuse of authorised veterinary medicines in food producing animals and investigate the reasons for residue violations. However there are some veterinary drugs that are prohibited, for safety reasons, from use at any stage in the raising of food producing animals. These are shown in Table 3. [29] Non-EU countries exporting to the EU must implement a residue monitoring plan which guarantees an equivalent level of food safety. [30]

Table 3 Veterinary medicines for which no MRL can be established

Residue	MRPL*	Residue	MRPL*
Aristolochia spp.		Dapsone	
Chloramphenicol	0.3 µg/kg	Dimetridazole	
Chloroform		Metronidazole	
Chlorpromazine		Nitrofurans	1.0 µg/kg
Colchicine		Ronidazole	

* If applicable

It was initially left to analytical chemists to define what 'zero' meant for banned veterinary compounds. A 'Decision Limit' (CCα), the measured concentration at which it can be said with 99 % statistical confidence that a prohibited substance is truly present, can be experimentally derived from method validation studies. These data points were necessarily specific to a particular test method operated in each laboratory, giving rise to the possibility that different laboratories might derive a different CCα, for the same method. To ensure that non-compliance decisions from different laboratories did not differ too markedly, and that results were mutually acceptable, in 2003 the European Commission introduced the concept of a Minimum Required Performance Limit (MRPL). In time, the MRPL became, for some banned drugs, a 'reference point for action', which may be construed as a *de facto* maximum limit also shown in Table 3. [31] However, emphasising that the designation of the MRPL as a reference point for action is not completely the same as a maximum residue limit, findings below the MRPL but above the CCα must be collated and investigated.

Against this complex background were superimposed practical difficulties of sampling and division of a sample into three equivalent portions to allow counter analysis by a food business and referee analysis by the Government Chemist. Since food law is criminal law, we viewed the transition from a validation based decision on presence or absence to a *de facto* maximum limit to invoke considerations of measurement uncertainty within the UK adversarial criminal justice system with attendant proof 'beyond reasonable doubt'.

Although no veterinary residues cases were received in 2013 we reviewed the issues and, in 2014 published the outcomes of our deliberations and dealt with three new cases..
The cases that had prior to 2013 involved only the nitrofuran family of antibiotics in 2014 also included chloramphenicol. Two nitrofuran cases were dealt with. In the first we did not detect marker metabolites in the retained portion. However, we had inadvertently been sent the reminder of the Public Analyst's portion of the sample in which we confirmed a concentration, above the MRPL of 1.0 µg/kg of 3-amino-oxazolidinone (AOZ), the marker metabolite of the nitrofuran drug furazolidone. In the second case AOZ, at 32.4 µg/kg, resulted in the rejection of the consignment.

[28] Cajka, T., Sandy, C., Bachanova, V., Drabova, L., Kalachova, K., Pulkrabova, J., & Hajslova, J. (2012). Streamlining sample preparation and gas chromatography–tandem mass spectrometry analysis of multiple pesticide residues in tea. Analytica chimica acta, 743, 51-60.
[29] Commission Regulation (EU) No 37/2010 of 22 December 2009 on pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin, the Annex, Table 2
[30] European Commission, Residues of Veterinary Medicine, http://ec.europa.eu/food/food/chemicalsafety/residues/index_en.htm (accessed 25.01.2015)
[31] Commission Decision 2003/181/EC of 13 March 2003 amending Decision 2002/657/EC as regards the setting of minimum required performance limits (MRPLs) for certain residues in food of animal origin, and Commission Decision 2005/34/EC laying down harmonised standards for the testing for certain residues in products of animal origin imported from third countries.

The chloramphenicol case yielded concentrations of not less than 0.6 µg/kg in one sample and not less than 0.26 µg/kg in a second resulting in the first consignment being prohibited from entering the food supply chain.

Our peer reviewed publication on nitrofurans [32] noted discrepancies between results. Despite international harmonisation of test methods and quality criteria, there continue to be differences between findings pre-harvest and pre-export in some countries, and results from Border Inspection Posts' analyses when consignments arrive at their destination. Forensic issues around enforcement decisions following laboratory results for non-compliant consignments containing nitrofurans were summarised, including those that have been referred to us for technical appeal. Current best practice was collated and specific recommendations and suggestions made for the decision-making process in food safety enforcement. Because it can be naturally occurring in the shells of crustaceans, analysis for semicarbazide, a nitrofuran marker, must be carried out on core flesh for confirmatory purposes. We also remove ice glaze prior to analysis. We advocate that measurement uncertainty should be subtracted from the mean result to yield a 'not less than' figure for reporting purposes 'beyond reasonable doubt'. Research is needed to fill knowledge gaps with regard to sample homogeneity and sampling protocols for nitrofurans in food of animal origin. Sampling should be standardised, as has been established for mycotoxin controls and a modern toxicology risk assessment of nitrofurans and their metabolites in food appears to be warranted. We subsequently were informed that EFSA is indeed conducting a review of nitrofuran toxicology.

Food labelling

In 2014 we were asked to review opinions on food labelling. This was a new departure for the Government Chemist and we investigated two alleged labelling non-compliances and offered advice. We are grateful to each party in both cases for their helpful written reports that were made available to us. In the first instance separate opinions by two Public Analysts were thought to be contradictory and clarification was requested from the Government Chemist. However careful examination of each opinion revealed they were essentially in agreement. We explained this in detail and affirmed the changes that were required to render the label compliant. In the second case no analysis had taken place and neither of the previous opinions (Public Analyst and commercial laboratory) was based on the same set of information. Each had come to valid conclusions that were not mutually exclusive with appropriate caveats. We set out the legislative framework and then focused our opinion on aspects of the label that appeared non-compliant. However, we recommended that the matter could only be resolved by analytical investigation and recommended that the matter be referred back to the Public Analyst for analysis.

Aflatoxins

Issues in the remaining two cases, those of the naturally occurring genotoxic carcinogens, aflatoxins, in food and feed have been dealt with in previous annual reports. A novel feature in 2014 with regard to aflatoxins was publication of our investigations of analytical recovery of these compounds. Recovery correction of aflatoxin results is mandatory in official analysis for which the only practical approach is separate determination of the analyte added either to aliquots of the sample or matrix blanks, a process commonly referred to as 'spiking'. Variations in the spiking contact times before extraction could have an effect on the recovery of aflatoxins from the matrix. We described two studies, a short term (0.5 – 65 hours) and a long term (1 hr - 8 weeks) investigation of the effect of contact time on spike recovery in peanuts, figs and chilli powder. Generally it was found that recovery is dependent upon contact time and this effect is statistically significant for short contact times (less than 24 hours) while thereafter the recovery stabilises. The results from both studies indicated a small effect on contact times in some matrix/aflatoxin/storage condition combinations, however any effect is statistically insignificant compared to the typical dispersion of results obtained in our hands by the method applied to the matrices analysed. [33]

Conclusions

In reviewing the outcomes of the technical appeals that were referred to us in 2014, we find that we uphold the results of official analyses in some 85 % of occasions. The reasons that some official and, more often, trade laboratory results are overturned include differences in sampling and methods of analysis with some sub-optimal methods being deployed. The chemistry or molecular biology of the product or analysis may be overlooked, and stochastic effects can introduce disputes on findings close to legislative limits. Many disputes, however, arise because of lack of awareness of context. Contextual oversights we have observed in casework include lack of knowledge of appropriate limits, inappropriate calculation of results, lack of proper application of measurement uncertainty, lack of regard to the population sub-group exposed, over-reliance on instrumental 'black box' algorithms, lack of awareness of naturally occurring compounds, poor presentation of results and lack of adequate datasets covering natural variation. When we uphold one set of findings against another the reasons will be clear in our reports to the parties concerned. Moreover, our publications often highlight such problems and we are careful to disseminate the collective learning for the analytical community anonymously at our knowledge transfer events.

It is a pleasure to acknowledge the assistance of colleagues in LGC and co-authors, principally Professor Duncan Thorburn Burns, who has given generously of his time and expertise in drafting the outcomes of our work for peer reviewed publication, a key measure of transparency in the discharge of the Government Chemist statutory function.

[32] John Points, D. Thorburn Burns, Michael J. Walker, 2014, Forensic issues in the analysis of trace nitrofuran veterinary residues in food of animal origin, Food Control, 50, 92-103

[33] Kirstin Gray, Dionisis Theodosis, Magdalena Mazur, Jesus Minguez, Simon Cowen, Selvarani Elahi and Michael Walker, 2014, Effect of Spiking Contact Times on the Analytical Recovery of Aflatoxins, J Assoc Public Analysts (Online),42, 18-34

3 Impact

The impact of the work of the Government Chemist programme is necessarily broad and the effects can be seen in a number of ways.

Horizon scanning is carried out to identify and prioritise the issues where referee cases are more likely to arise, or where new regulation/legislation may lead to food business operators and local authorities requiring advice or support. Research projects are carried out to support those areas identified. These projects have benefits beyond the referee analyses carried out under the Government Chemist's statutory function, and often impact on the wider measurement community to prevent disputes by promoting best measurement practice in emerging areas of threat. Project outputs are disseminated through knowledge transfer activities (which are detailed later in this review) and a list of publications is given later in this section. The advisory function of the Government Chemist provides advice on a breadth of analytical measurement subjects, in the regulatory and legislative context, to government, the European Commission, and the wider stakeholder community.

All these activities are aimed at predicting future regulatory issues within the areas of chemical and biochemical measurements with the objective of providing a secure base for more efficient and cost-effective regulations.

Horizon scanning

Preparedness for future problems is enhanced by our horizon scanning of the scientific implications of policy development, emerging and changing legislation, and enforcement trends. We publish our foresight activities, such as our reviews on legislation with a commentary on the associated scientific context, on our website. We collaborate with the Institute of Food Science and Technology (IFST), the Department for Environment, Food and Rural Affairs (Defra) and the Association of Public Analysts (APA) Training Committee, gaining and sharing insights on developments in the food industry and the official food and feed control system. An exciting novel aspect of our horizon scanning is our ongoing collaboration with Kingston University, co-funded by the Food Standards Agency, to enhance intelligence gained from multinational food recalls datasets. This work explores the usefulness of interactive data mining of emerging or re-occurring temporal trends in global food safety and authenticity issues, and builds on the expertise and experience at Kingston University in the application of novel algorithms in network analysis coupled with web-based visualisation of outputs.

Meat and fish authenticity testing

The issue

The current UK and world economic climate dictates that there is an increased propensity for adulteration of expensive foods using cheaper species and ingredients, as evidenced by the EU horse meat issue which arose in 2013. The findings of horse DNA present in beef burgers sold in a UK supermarket chain highlighted the need to provide support for rapid and reliable appraisal of the meat supply chain by developing standardised approaches for the detection and quantitation of different meat products.

The presence of undeclared species can have religious, ethical and economic repercussions for consumers, whose confidence in meat products was affected directly by the horse meat scandal. This has led to heightened awareness of further meat contamination/adulteration that may be prevalent, including provision of meat produce intended for faith groups (e.g. pork in beef).

In addition, the UK is consuming increasing quantities of fish and reports in the published literature and the press describe increased occurrences of fish substitution. The extent of fish fraud was highlighted in 2013 (University College Dublin)[34] where up to 25 % of 150 portions of fish sold as cod in fishmongers, supermarkets, takeaways and restaurants were reported as being labelled incorrectly. Cheaper fish species are being substituted for higher grade species (e.g. Vietnamese catfish being labelled and sold as cod), which has economic, and fish sustainability implications.

The lack of traceability of some food ingredients and species, coupled with a deficit in the maintenance and development of reliable analytical tests to detect and quantify meat and fish species of interest, has highlighted the need to develop and maintain effective systems to predict, monitor and test food chains for likely food and ingredient adulteration.

The solution

Core expertise in established molecular biology analytical techniques for identification and quantitation of traditional animal species is being reviewed, developed and maintained. In addition to this, new molecular biology approaches necessary to address novel and emerging species used in food fraud are being evaluated.

Development and maintenance of fish speciation

Government Chemist capability for fish speciation has been reinforced through participation in a ring-trial of a DNA sequencing method, originally developed under the 'Labelfish' EU project. The Labelfish project involved an EU InterReg funded network of laboratories in the 'Atlantic Area' of Europe, aimed at developing harmonised and standardised methods for the authentication of seafood products. The Government Chemist has helped test and verify a DNA sequencing method developed during the project that uses a DNA barcoding approach (mitochondrial Cytochrome I sequencing) for identification of fish species. The Government Chemist has provided feedback and comments to the trial organisers (University of Salford) as to the ease of use and robustness of the original draft Standard Operating Procedure (SOP). We were involved in a ring-trial of the SOP using 13 blind samples, inclusive of sample preparation, DNA extraction, PCR amplification and quality control, DNA sequencing, generating a consensus DNA sequence, use of bioinformatics, and identifying the species on the barcode of life database. The results of the ring-trial are currently pending, but the feedback the Government Chemist received with respect to the submitted results was very encouraging.

[34] UCD News 23 April 2010 http://www.ucd.ie/news/2010/04APR10/230410_cod.html

Competency in determining fish country of origin labelling

Illegal fishing and mislabelling within the supply chain represents a growing problem with serious ecological and economic consequences. Building upon the UK coordinated EU-FP7 FishPopTrace research project, the Government Chemist participated in Defra project FA0118, which aimed to develop geographic traceability tools for commercial fish and fish products. The Government Chemist undertook assay validation activities that involved the transfer and optimisation of a draft validated protocol, evaluation of the component SNP KASP-based[35] assays and limited robustness testing. Additional DNA extraction work was supplemented through Government Chemist funding. The work confirmed that the underpinning SNP-based genetic approach was capable of distinguishing between specific regional populations within a fish species and unaffected by the limited number of assay/processing conditions examined. The project builds upon existing expertise and enhances core capabilities within key areas such as fish population genetics, SNP-based forensic approaches and the application of novel chemistries to food-based diagnostics, and contributed towards the development of a Defra SOP with potential application within the Public Analyst network.

Appraisal of new and emerging molecular biology approaches

The use of emerging DNA technologies (e.g. digital PCR (dPCR) and DNA sequencing) for meat identification and quantitation is currently being reviewed and evaluated experimentally. The Government Chemist was represented at a three day workshop in Italy during November 2014, led by the EU Reference Laboratory for Genetically Modified Organisms in Food and Feed (EURL-GMFF), aimed at exploring the application of dPCR in the field of genetically modified organism (GMO) and food authenticity testing. The Government Chemist was also consulted as part of a working group discussing the use of dPCR for routine testing of food samples in order to identify GMOs. Maintenance of capability in the area of dPCR will be essential if the technique is to be employed for EU GMO control purposes in the future.

A report is currently being written regarding a review on the use of new and emerging DNA technologies with respect to their applicability for meat and fish speciation, with a focus on a variety of PCR based approaches, DNA sequencing and dPCR. Important advantages and limitations of each approach are summarised and key recommendations for the use and implementation of new and emerging DNA technologies and their future potential use are provided.

Government Chemist advice and dissemination

Government Chemist advice and input has been provided at Defra's Authenticity of Methods Working Group (AMWG) and associated sub-group meetings through 2014, regarding food authenticity testing issues. In particular, the Government Chemist has actively contributed towards the Defra and AMWG response to the Elliott review [36] that was published in September 2014 and included a list of recommendations regarding the food adulteration related issues following on from the horse meat issue in 2013.

In terms of dissemination, a peer reviewed paper has been published in the Journal of the Association of Public Analysts [37], regarding the validation of the Limit of Detection (LOD) for assays used for detection of horse DNA as part of the original UK beef product survey in 2013. This paper describes some of the work that was conducted in order to demonstrate that a LOD of less than 0.1% w/w raw horse meat in a raw beef (meat) background could be achieved, if quality procedures and good laboratory practice for molecular biology methods were adhered to. This helped afford good comparability of results for the methods, and in turn contributed to ensuring that the results from the UK survey of beef products in 2013 were interpreted with confidence.

[35] LGC's proprietary genotyping technology

[36] Elliott Review into the Integrity and Assurance of Food Supply Networks – Final Report: A National Food Crime Prevention Framework, July 2014 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/350726/elliot-review-final-report-july2014.pdf

[37] Eloise Busby and Malcolm Burns (2014) "Method Verification of the LOD Associated with PCR Approaches for the Detection of Horse Meat" Journal of the Association of Public Analysts 2014 (42): 001-017. http://www.apajournal.org.uk/2014_0001-0017.pdf

Additionally, a further peer reviewed paper has been published in the Journal of the Association of Public Analysts [38] with respect to the development of a simple end-point PCR and capillary electrophoresis (CE) approach for the detection of a set of crop species in processed foods. The publication is based on Government Chemist work in the area of food authenticity testing, and describes a screening approach for the simultaneous detection of lupin, maize, soya, cotton and sugar beet in food samples, which can be readily implemented in any analytical testing laboratory.

Future work

Within the time frame of the current Government Chemist programme 2014-2017, work will be conducted in order to gain a better understanding of the fundamental issues of meat identification and quantitation, including investigation into DNA expression units and the impact of food processing on meat identification and quantitation.

What are the expected outcomes?

The expected outcome from this work is the provision of demonstrable evidence for the maintenance of core expertise and development of improved methods for detection, identification and quantitation approaches of adulterant meat/fish species to support legislative requirements. This work will continue to position the Government Chemist at the forefront of taking a proactive role in providing appropriate advice on fundamental meat and fish speciation analytical issues and allow him to disseminate best measurement practice guidance.

The work outlined here will permit accurate species detection ensuring correct labelling of products, helping prevent fraud and adulteration, minimising unfair trade and raising consumer confidence. Correct meat and fish speciation will help towards traceability of animal products from around the world, permit monitoring of their potential overuse, evaluate their sustainability and assess the impact upon the environment and biodiversity.

Accurate meat/fish species identification and quantitation helps establish a verifiable claim that can be tested for authenticity. This helps underpin consumer choice based on health, religious and cultural reasons.

The Government Chemist has also invested in building competency in the area of sample preparation for meat species. Accurate, reproducible and representative sample preparation is central to all fish and meat speciation and quantitation activities. Work has been undertaken to optimise protocols and increase in-house capability for the generation of gravimetrically prepared meat ad-mixtures. Sample preparation and homogenisation of meat materials have been investigated and verified experimentally. Capability has been demonstrated for emulating adulteration in processed food materials by spiking in cooked meat materials into commercial food products on a gravimetric w/w basis to provide a range of standards and test samples. Subsequent DNA extraction and analyses have confirmed that the ad-mixtures are fit for purpose as characterised by determined experimental percentage adulteration values and associated uncertainties. Related work has commenced to investigate the measurement issues and uncertainties associated with ad-mixtures prepared using processed meat samples at the legislatively important 1% adulteration threshold level.

Comparison of different DNA approaches

Fundamental research and guidance on DNA extraction and use of different DNA targets for meat and fish speciation has been undertaken to help maintain referee capability in this area.

Evaluation of different DNA targets

Experimental work has been conducted to establish the fitness for purpose of mitochondrial and nuclear DNA targets for meat identification and quantitation. Published literature suggests that genomic DNA may be the preferred target for meat quantitation due to its stable copy number between tissues, whilst mitochondrial DNA could be the better choice for sensitive detection of meat species due to its relative abundance. However, little experimental evidence in the published literature has been presented on the subject.

The Government Chemist has conducted a review of the current scientific literature that highlights the dominance of mitochondrial-based approaches. Experimental data has been collated to effectively compare the application of mitochondrial and nuclear DNA targets to effective meat quantitation. Following a review of current literature/methodologies and recent meat adulteration related cases, the adulteration of beef with horse muscle tissue was selected as an appropriate model test system. Initial work has focused on the comparability of DNA test samples extracted using different DNA extraction systems prior to investigating the quantitative capabilities of a non-proprietary genomic-based relative quantitation assay and a commercial mitochondrial-based relative quantitation test kit. Work in this important area is ongoing, and experimental data is being produced regarding the application of genomic and mitochondrial assays for the quantitation of meat and offal material. Additionally, the lower limits of applicability (biological sensitivity and limits of detection) for the genomic and mitochondrial assays will be evaluated, in order to provide the Government Chemist with objective evidence of the fitness for purpose of the alternative DNA targets under specific situations.

A capability building exercise was carried out by assessing the feasibility of using the in-house CTAB method for the extraction of

[38] Eloise Busby and Malcolm Burns (2014) "A Simple DNA-Based Screening Approach for the Detection of Crop Species in Processed Food Materials" Journal of the Association of Public Analysts 2014 (42): 035-060. http://www.apajournal.org.uk/2014_0034-0060.pdf

genomic DNA from a selection of highly processed meat products (pate). It was noted that the CTAB method was successful in obtaining very good yields of high purity DNA from this material.

Future work in the important area of DNA extraction and use of DNA targets will include evaluating quantitation of DNA and relative mass per mass content of food samples, investigating the relationship between DNA copy numbers and actual meat content, and assessing the impact of food processes on DNA measurement.

Expected outcomes in the area of evaluating DNA extraction approaches and choice of DNA target will facilitate improved advice and cost and time efficiency savings for referee analysis of new and arising meat and fish speciation issues.

Timber authenticity – a topic of growing importance

The issue

The EU Timber Regulation (995/2010) prohibits the placing of 'illegally harvested' timber and timber products on the European market and lays down obligations on those who buy and sell timber to exercise a due diligence process to minimise associated risk of this happening. Where timber or timber products have already been placed on the market, 'traders' must be able to identify their 'suppliers' and, where applicable, their 'customers', to enable the tracing of timber. The regulation entered into force on 2 December 2010, and applied to all timber operators and traders in the EU from 3 March 2013.

Some common practices associated with illegal logging are the false declaration of:

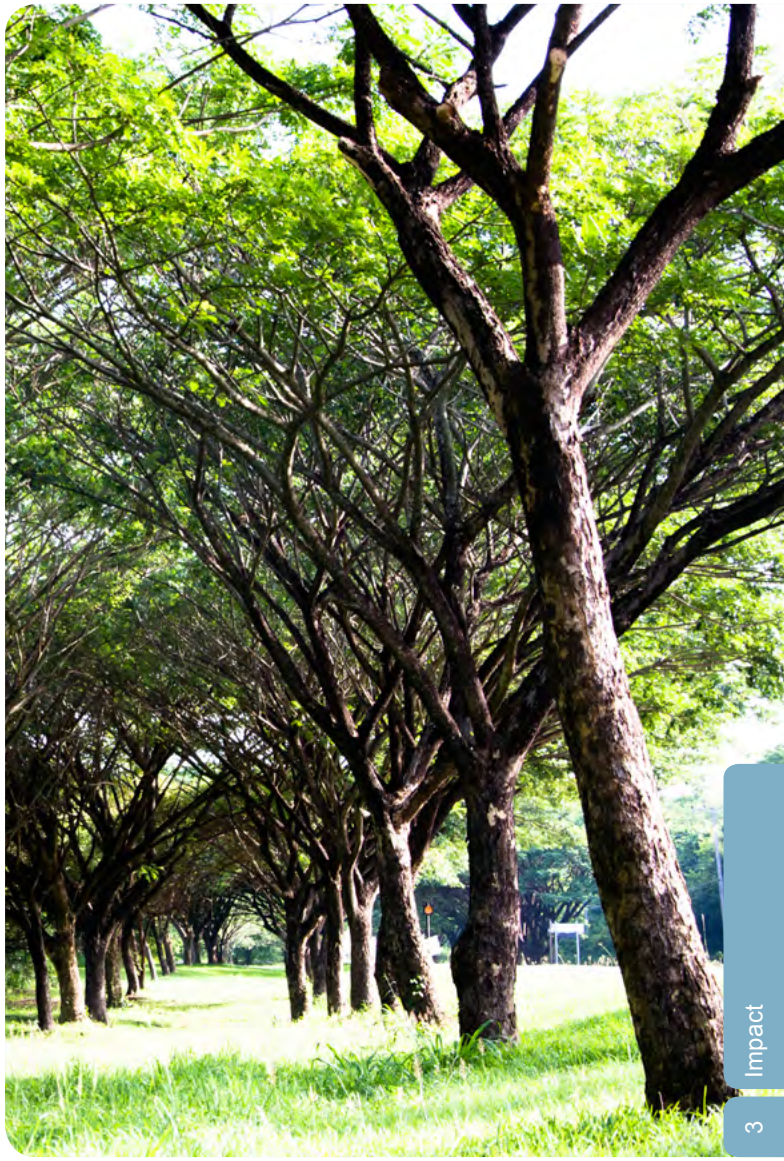
- **Species** when the harvested wood is an endangered species or a species excluded from legal harvest in a particular country or region;
- **Country of origin/geographical region** when export of a particular species is allowed in one country/region but banned from another;
- **Individual trees** that have been harvested outside of a registered concession or from inside a protected area.

The solution

Methods available for timber authentication

Despite the introduction of the Regulation to combat illegal logging, there is a lack of practicable control mechanisms to identify the origin of timber and wood products. Such analytical methods are essential for efficient import controls or origin testing by 'traders'.

Existing morphological methods based on light, UV, atomic force microscopy (AFM) or confocal microscopy and image analysis of fibre length, require a high degree of specialist knowledge making them largely impracticable. Other reported methods include densitometry, nano-indentation, direct elution mass spectrometry (e.g. global mass fingerprinting of lignin and polysaccharides pyrolysis compounds), near-IR spectroscopy and High Resolution-computed tomography.



Stable isotope ratio analysis has been the standard approach adopted for the verification of origin of products in the food and feed sector. Elemental analysis of timber and wood products is used less in forestry applications than agriculture due to the wider variability of forest soils, but may add corroborating evidence. The method has been proven reliable and was employed by the American EIA (Environmental Investigation Agency) in 2013 to verify results of investigations into illegal timber imports from Russia. However, it is expensive to implement and is heavily dependent on the availability of isotope distribution data, a factor that requires regular revision.

Recent progress to isolate DNA from wood and wood products offers new opportunities to test the declared origin of timber and timber products. Genome size and genetic variation within most forest tree species is highly variable in comparison to other organisms. This presents opportunity and challenge to definitively identifying origin.

A study is currently being carried out under the Government Chemist function to:

- Develop and validate analytical procedures for the extraction of DNA from untreated, and treated timber products;
- Investigate feasibility of DNA extraction methods for processed timber products;
- Develop robust DNA profiling assays for species identification and geographical location for selected priority species and geographical locations.

Initial work has focussed on the identification of oak *(Quercus)* species.

Oak timber has been reported as being employed extensively for the purpose of construction (buildings and maritime purposes), flooring, and furniture. Those species more frequently reported as being employed in construction and the production of furniture include the red and white oak species, *Q. rubra and Q. borealis*, but also includes the eastern black oaks (*Q. velutina*), scarlet oaks *(Q. coccinea),* pin oaks *(Q. palustris),* and southern red oaks *(Q. palcata),* although these are generally considered to be of an inferior quality.

The use of DNA for the molecular phylogenetic study of Quercus has been cited in numerous scientific publications [39, 40, 41, 42]. Nucleic acid extraction from both oak leaf and timber have been reported, as well as for fresh, dried, preserved, and water soaked samples.

DNA extraction

The analysis of DNA is possible in untreated timber, but optimal selection of the sampling section of the tree is important as DNA concentrations differ in different parts of the trees. The quality and quantity of extracted DNA from wood is inferior (partially degraded and rarely free from inhibitory substances) to that extracted from fresh 'green' tissue, regardless of the chosen extraction method. Extraction from processed wood is even more difficult. Mechanical disruption of wood, heating, pressure, application of glues or other chemicals, and other treatments may result in almost complete degradation of DNA, so limiting ability to determine origin.

A range of nucleic acid extraction approaches have been described in the literature, including: DNeasy Plant mini kit (Qiagen); modified CTAB; Nucleon Phytopure® (GE Healthcare), and GMO BioKit® (GE Healthcare). A modified protocol for the DNeasy Plant mini kit as reported in Rachmayanti *et al* [43] is currently considered as the best and most effective extraction method for use with oak, primarily due to its low cost, simplicity of use, and throughput capacity.

Molecular markers

Plant cells contain DNA in the nucleus (nDNA), mitochondria (mtDNA), and chloroplasts (cpDNA). The choice of the most appropriate molecular marker to trace the origin largely depends on the species and the current knowledge about spatial distribution patterns of genetic diversity. While genetic variation is more conserved in cp- and mtDNA in comparison to nDNA, differentiation among populations is often much higher. Thus, variation patterns of maternally inherited cp- or mtDNA haplotypes are often suitable for phylogeographic studies and hence useful to distinguish the origin of trees on a large geographic scale.

The DNA database of International Barcode of Life project (iBOL), which is a DNA-based identification system for identifying known species and discovering new ones, currently contains information on 96 species of *Quercus*, from 28 countries, and sequence for a combination of appropriate molecular markers. Identification of molecular markers for the identification of oak species has been hampered for a number of reasons, including poor species delineation and interspecific hybridisation. To date, phylogenetic reconstructions based on DNA sequences have demonstrated poor levels of resolution. An improvement in the level of resolution obtainable has been described by Manos *et al* [44], who included regions of the internal transcribed spacer (ITS) between the structural ribosomal RNAs for the construction of their phylogenetic trees. Inclusion of markers from the ITS region allowed differentiation of the *Cerris, Erythrobalanus, Protobalanus* and *Lepidobalanus* sub-genus groups. More recently [45], it has been demonstrated that similar levels of resolution could be obtained using cpDNA markers alone provided the chloroplast trnD-trnT intronic sequence was included in the panel of markers.

[39] Lowe, A. Can we use DNA to identify the geographic origin of tropical timber. in Proceedings of the international workshop "Fingerprinting methods for the identification of timber origins" October. 2007.
[40] Asif, M. and C.H. Cannon, DNA extraction from processed wood: a case study for the identification of an endangered timber species (Gonystylus bancanus). Plant Molecular Biology Reporter, 2005. 23(2): p. 185-192
[41] Deguilloux, M.F., M.H. Pemonge, and R.J. Petit, Novel perspectives in wood certification and forensics: dry wood as a source of DNA. Proc Biol Sci, 2002. 269(1495): p. 1039-46.
[42] Deguilloux, M.-F., M.-H. Pemonge, and R.J. Petit, DNA-based control of oak wood geographic origin in the context of the cooperage industry. Annals of Forest Science, 2004. 61(1): p. 97-104.
[43] Rachmayanti, Y., et al., Extraction, amplification and characterization of wood DNA from Dipterocarpaceae. Plant Molecular Biology Reporter, 2006. 24(1): p. 45-55.
[44] Manos, P.S., J.J. Doyle, and K.C. Nixon, Phylogeny, Biogeography, and Processes of Molecular Differentiation in Quercus Subgenus Quercus (Fagaceae). Molecular Phylogenetics and Evolution, 1999. 12(3): p. 333-349
[45] La, X., Diversité de l'ADN chloroplastique et relations phylogénétiques au sein des Fagacées et du genre Quercus. 2004, Université Henri Poincaré: Nancy. p. 129.

From the results of the molecular phylogenetic studies published to date, a number of molecular markers have been identified that could be used in the identification of oak timber and related products. These include the chloroplast DNA sequences rbcl, the atpBE intergenic spacer, and the 3' trnK intron [46], the nuclear ribosome sequences ITS1 and ITS2 [47], [48], and the single copy nuclear genes CRC [49]. All, or a combination of the targets, could be employed to determine the presence and species of oak from which a sample is comprised.

Future prospects

The development of cost-efficient nucleic acid extraction and genotyping methods based on high-throughput sequencing is likely to greatly improve possibilities to assign samples to heterogeneous, poorly differentiated groups based on multilocus genotypes at least for intensively studied 'model' species.

Knowledge transfer

The Government Chemist seeks to benefit innovation and regulation by dissemination of knowledge gained through our work, particularly in referee analysis. This dissemination is aimed at both the analytical and regulatory communities to improve knowledge and skills through a coherent package of knowledge transfer activity which includes:

- The organisation of the Government Chemist conference (on a biennial basis);
- The publication of case studies based on actual referee analysis;
- The organisation of training in collaboration with the APA Educational Trust, the Food Standards Agency and Defra;
- Proactive input to key stakeholder organisations;
- Provision of sound advice to stakeholders.

Government Chemist conference

The biennial Government Chemist conference is an important event in the programme calendar, with the 2014 event, themed "Beating the cheats: Quality, safety and authenticity in the food chain", attracting more than 150 delegates over the two-day event.

The audience of public analysts, government officials, industry and public sector scientists, academics and leading food experts heard how sound measurement science has a fundamental part to play in ensuring the safety and integrity of the food chain.

The conference featured presentations on referee cases and the latest analytical techniques that can be used by manufacturers to monitor their production processes, by suppliers to test their produce and by enforcers to ensure compliance with regulations. This included the latest techniques for determining the species of meat in processed food and for assessing whether carry over occurs in meat processing plants. The audience heard how isotope ratio measurements can be used to help determine the origin of foods and therefore establish authenticity and the accuracy of labelling.

The Food Standards Agency outlined the steps they have been taking to prepare the industry for legislation changes – particularly the new allergen labelling rules that came into force on 13 December 2014. The presentation outlined 'good practice' and emphasised that while customers need to ask for information about allergens, caterers need to ensure that all of their staff know when allergens are present in the food they provide.

Professor Chris Elliott's keynote presentation, "Securing the integrity of our food supply", provided the context for the conference and included updates on the changes that are being made across the food industry following his official review into the integrity and assurance of food supply networks that was triggered by the horse meat incident in 2013.

The spotlight turned on food fraud outside the UK during a talk by Michael Rosenmark, from the Danish Food Flying Squad, which provided an insight into the work of his specialist unit and the powers it has to tackle food crime in Denmark. Yiu-chung Wong, from the Government Laboratory in Hong Kong discussed the authentication of Chinese medicinal food and the detection of marine toxins in seafood.

The conference, which was held at the Royal Society, London, on 24-25 November 2014, received fantastic feedback from the delegates. Many of the presentations were recorded and are available to listen to on the Government Chemist web pages at GOV.UK. Search for "Beating the cheats" to find all of the information about the conference.

[46] Manos, P.S. and A.M. Stanford, The historical biogeography of Fagaceae: tracking the tertiary history of temperate and subtropical forests of the Northern Hemisphere. International Journal of Plant Sciences, 2001. 162(S6): p. S77-S93.
[47] Samuel, R., et al., ITS sequences from nuclear rDNA suggest unexpected phylogenetic relationships between Euro-Mediterranean, East Asiatic and North American taxa of Quercus (Fagaceae). Plant Systematics and Evolution, 1998. 211(1-2): p. 129-139.
[48] Bellarosa, R., et al., Utility of ITS sequence data for phylogenetic reconstruction of Italian Quercus spp. Molecular phylogenetics and evolution, 2005. 34(2): p. 355-370.
[49] Oh, S.H. and. Manos, P.S., Molecular phylogenetics and cupule evolution in Fagaceae as inferred from nuclear CRABS CLAW sequences. Taxon, 2008. 57(2): p. 434-451.

Moving to GOV.UK

The Government Chemist website moved to GOV.UK in July 2014, as part of the Government's digital strategy to make public services simpler, clearer and faster to use. The new landing page is: www.gov.uk/governmentchemist

The Government Chemist pages can also be reached from anywhere on the site by entering 'Government Chemist' in the search box.

Only recent and relevant corporate information, research, news and policy content have transitioned to the new GOV.UK website.

The Government Chemist section on GOV.UK looks very different from the previous site. Like the rest of GOV.UK, information about the Government Chemist is clearly written and free of jargon, so anyone with an interest in what is happening under the Government Chemist programme will be able to understand it.

Updates on Government Chemist news can be obtained by subscribing for alerts via the website.

Advice

Many stakeholders turn to the Government Chemist for advice on a wide range of topics. We answer around 5 requests for advice per month, a level that has remained constant for the past few years. Table 4 below summarises who asked us for advice in 2014 and Table 5 describes the topics we were asked to comment on.

Reflecting the enhanced salience of food authenticity (e.g. geographic origin of food, provenance, added water in food) these enquiries topped the list in terms of numbers. Other topics such as evaluation of the choking risk posed by jelly mini-cups, allergen analysis and the interpretation of results, and nutrition analysis generated regular questions. In each case we gave carefully considered advice, supplying a copy of our peer reviewed research findings on the question and sometimes referring the enquirer to another source of information.

The enquirers were invariably grateful for our time and advice.

Table 4 Stakeholders asking the Government Chemist for advice in 2014

Origin of enquiry	Number of enquiries
Commercial / Industry / Consultant	18
Food Standards Agency	5
Individual	1
Media	3
Official Control Laboratories (Public Analysts)	10
Peer reviewed journal	2
Police forces / forensic	5
Port Health Authorities	2
Trading Standards / Environmental Health depts.	9
University dept.	1
Total	56

Table 5 Summary of topics we have advised on for advice in 2014

Subject	Number of enquiries
Allergens	7
Animal feed analysis	1
Drugs / toxins / poisons	3
Food Additives	2
Food Authenticity analysis	13
Food Contact Materials	2
Food Labelling	2
Irradiation	1
Jelly mini-cups choking risk	4
Meat speciation	3
Mycotoxins	1
Nutrition analysis	4
Scientific peer review	2
Other	11
Total	56

Training

The Government Chemist acquires a great deal of expertise and knowledge through discharging the statutory function. This forms the basis of material which can be used in the provision of training for practising analysts.

EU legislation and guidance on the detection of Chinese genetically modified (GM) rice varieties is complicated due to the challenge of the analytical testing methodology and the current production and authorisation procedures for GMOs inside and outside of the EU. In response to this, LGC hosted and led an interactive workshop on approaches for detecting Chinese GM rice for public analysts in June 2014, shortly after revised guidance was issued by the European Commission. The objectives of the workshop were to explore some of the issues surrounding the analyses and to make provision for PCR positive control materials provided by LGC for use in detection of Chinese GM rice. The workshop was funded by the Food Standards Agency (FSA) and supported through the UK National Measurement Office as part of the Government Chemist programme 2014-2017. Representatives from six public analyst laboratories, as well as from Defra and the FSA attended the workshop.

The day featured a review of the European Union Reference Laboratory guidance for the analysis of rice and rice products for GM events, with an overview of the recently revised parts of the guidance. Each public analyst laboratory provided a short presentation emphasising its experiences with GMO analysis and highlighted issues that they faced, which were debated as part of round table discussions. A key note speech was provided by Dr Nancy Roosens from the Scientific Institute of Public Health in Belgium. Dr Roosens spoke about the initial development of the SYBR® Green method for screening for Chinese GM rice and how this was incorporated into the European Union Reference Laboratory guidance. During the afternoon session delegates analysed example datasets, and discussed and agreed issues on the interpretation of results. The discussions held during the workshop highlighted some of the technical issues surrounding interpretation of results and the need for further harmonisation.

In September 2014, Malcolm Burns delivered an e-seminar on “GMO analysis and best measurement practice” organised by Separation Science, as part of a series of food safety analysis seminars. The e-seminar outlined the role of DNA and real-time PCR for GMO analysis, and introduced some of the key concepts in best measurement practice guidelines through the use of reference materials and involvement in external quality assessment exercises. Some of the analytical issues surrounding GMO analysis were explored, and the e-seminar was summarised by providing best practice guidance in this area.

LGC organised a knowledge transfer event “DNA extraction approaches to support food labelling enforcement” for public analysts, funded by Defra, the FSA and the Government Chemist. The event was held at LGC and provided a technical introduction to DNA extraction basics, reviewed diversity of sample types and discussed associated features, reviewed current Defra and FSA food authenticity protocols, summarised the spectrum of different DNA extraction methods currently available, provided suggested DNA quality metrics to adhere to, and discussed data interpretation. The workshop included a practical component and also provided an appropriate follow-up challenge exercise. The event concluded with a general question and answer session including topics covering the provision of advice and best practice guidelines for DNA extraction methodologies in food authenticity testing, as well as providing public analysts with an opportunity to feedback requirements to help steer future training events. The event was attended by 15 participants representing public analyst laboratories from across the UK, as well as Defra and the FSA. The event provided public analysts with an excellent opportunity to network, further enhance their skills, share experiences and discuss specific issues in relation to DNA extraction.

The Analysis and Examination of Foods 2014 - our joint flagship week-long residential course run in collaboration with the APA Educational Trust - was held at Reading University in April/May 2014. Eight delegates, all from Public Analyst laboratories, attended the training, which featured practical sessions on microscopy and microbiology as well as lectures and interactive exercises. We are again grateful to the guest lecturers from practicing public analysts, Defra, the FSA, the Drinking Water Inspectorate and other organisations. The public analysts’ laboratories represented some 250 local authorities in the UK and Isle of Man and delegates and speakers spanned both the private and public sector laboratories that make up the modern public analyst service. Further detail is available on the Government Chemist website.

Reflecting their utility when people are increasingly less able to travel away from their home laboratories owing to pressure of work and financial constraints, webinars are an increasing feature of our training. In 2014 we delivered a total of five webinars mainly with the cooperation of external organisations, three on allergen analysis, one on molecular biology and one on isotope ratio mass spectrometry.

The wider advisory function

The Government Chemist also has a role to provide advice on subjects with an analytical measurement dimension to both government (including the European Union and devolved administrations) and the wider community of stakeholders, which includes industry, academe and local government. This is done by means of the provision of specific advice pertaining to aspects of measurement topics on a broad range of policy and regulatory developments, and also providing a proactive scientific and measurement-based support service to those industries where chemical measurements are an important aspect of their activities.

Addressing scientific issues with stakeholders

We have continued to follow developments of both the UK Chemical Stakeholder Forum and the Hazardous Substances Advisory Committee (HSAC), the successor body to the Advisory Committee on Hazardous Substances, by attending meetings of these bodies and, where appropriate, making contributions to relevant discussions. We continue to be the *de facto* experts on analytical measurement issues within the HSAC, and have been frequently asked to provide an opinion on this where required. A good example of this was in the provision of advice to the committee on the analytical methodologies which can be used in the differentiation of ionic silver from nano-silver, which is of significant interest to the committee. A small lab-based study has been planned in support of this advice, and this has been warmly welcomed by the committee. More details about this work are given on page 29.

We have also been invited to become active members of the Government Officials Strategy Group on Nanomaterials, which is led and chaired by Defra. We have contributed to this group by making our views very clear on the need for valid measurement methods for the determination of nanoparticles to be developed in advance of a definition of a nanomaterial being agreed.

We have continued to provide advice through our responses to a wide range of official consultations (see Box 2). These consultations are carried out by the government (including devolved administrations and agencies), standards bodies or the European Union, to obtain the input of both interested and expert stakeholders on proposed new legislation or regulations, prior to enactment and are considered by legislators to be an important part of the development process for new legislation and regulation. The Government Chemist is well-placed, through the expertise within LGC in a breadth of matters in analytical science, to respond authoritatively and independently to a wide range of consultations which have chemical or bioanalytical measurement implications.

Specific questions which we addressed included:

- The need for statutory powers to cover forensic laboratories in both the public and private sectors;
- The need to ensure that validated analytical measurement methods are available to support proposed legislation for fragrance allergens, for new priority substances under the Water Framework Directive and for marine fuels with a lower sulfur content;
- The need to co-operate and invest in the development of traceable measurement procedures for identifying and quantifying allergens in foodstuffs;
- The inclusion of formaldehyde as substance of concern that should be given equal prominence to other fumigants as it is a common fumigant for microbiological containment laboratories and facilities;
- The need to have validated and metrologically-sound methods of measurement in place to enforce and monitor allergen label claims appropriately.

Box 2: Our public consultation responses

Home Office	Consultation on new statutory powers for the forensic science regulator
Department for Transport	Specifying a limit for amphetamine in regulations for the new offence of driving with a specified controlled drug in the body above the specified limit – A consultation document
European Commission DG Health	Public consultation on fragrance allergens in the framework of Regulation (EC) No. 1223/2009 of the European Parliament and of the Council on cosmetic products
Defra/Welsh Government	Water Framework Directive implementation in England and Wales: new and updated standards to protect the water environment
Maritime and Coastguard Agency	Consultation on the draft Merchant Shipping (Prevention of Air Pollution from Ships) and Motor Fuel (Composition and Content) (Amendment) Regulations 2014 implementing EU Directive 2012/33/EU on the sulphur content of marine fuel
European Food Safety Authority	Consultation on the evaluation of allergenic foods and food ingredients for labelling purposes, by the EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA)
Health and Safety Executive	Guidance - Fumigation: Health and safety guidance for employers and technicians carrying out fumigation operations (HSG251) - Revised draft for information and comment

Dissemination

During 2014, we continued to promote the Government Chemist blog[50] which we use to communicate stories and issues where legislation and regulation meet analytical measurements. The blog is aimed to be informal and a means to make stakeholders aware of a range of issues of interest.

We have also been invited to give a talk on the activities of the Government Chemist advisory function at the 59th meeting of the United Kingdom Chemical Stakeholders Forum (UKCSF) in January 2015.

Taking our advice into new areas

We have provided advice in new areas during 2014. We were widely consulted by the Department for Transport regarding a problem with some diesel fuel in a specific area of the country which was solidifying in cold weather and blocking fuel filters in various vehicles. We used our expertise in analytical measurement issues to help design experiments to look at the chemical aspects of this problem and review the data from tests carried out.

We have provided advice to HM Revenue & Customs and HM Treasury on the chemical aspects of the proposed regulation to allow the addition of 95 % aqueous methanol to gasoline as a fuel extender, attracting a lower rate of excise duty. We gave advice to show the maximum level that could be safely added before the water content became a problem.

We have participated in a stakeholder meeting organised by Defra entitled "Public Dialogue to Understand the Perceptions of Specific Applications of Nanotechnologies" to develop case studies and approaches for public dialogue events.

We have organised a seminar to be held in Birmingham in March 2015. It is a repeat of the successful 2013 seminar "REACH and CLP enforcement: measurement and related issues for Public Analysts and Enforcement Authorities" following a request from the Training Committee of the Association of Public Analysts.

[50] http://governmentchemist.wordpress.com/

Lab-based studies

The prioritisation process undertaken by the GCWG prior to the commencement of the 2014-2017 programme identified a small number of proposed project areas which were considered appropriate for small-scale funding. Other small-scale projects have been, and will continue to be, developed in response to issues which surface during the programme.

No further studies were concluded in the last year under the 2011-2014 programme. The following study was concluded under the 2014-2017 programme:

An MSc student from Loughborough University carried out a four-month study funded by the Government Chemist advisory function at LGC's Teddington laboratories entitled "Application of Liquid-liquid Extraction for Pre-concentration and subsequent determination of polybrominated diphenyl ethers (PBDEs) by inductively-coupled plasma-isotope dilution mass spectrometry (ICP-IDMS) in environmental water samples". This was a very successful project which has contributed significantly to the development of a method which is capable of measuring PBDE in environmental water samples (groundwater, river water) at or below the Environmental Quality Standard (EQS) level stipulated in the EU Water Framework Directive (WFD) and its daughter directives. These toxic and persistent compounds were determined quantitatively at sub ng/L levels, which has not previously been achievable. This work is complementary to the desk study on analytical implications of the Water Framework Directive which is also being carried out in this part of the programme.

Other projects have been started in this part of the programme which will be completed during 2015 and 2016. These are:

- Identification of sustainable timber (see article on page 23)
- A desk study looking at the current and proposed priority hazardous substances and priority substances listed in the Water Framework Directive and its daughter directives, with specific reference to the ability of environmental monitoring laboratories to measure these compounds accurately at the maximum levels laid down in the regulations. The report will highlight where gaps in measurement capability exist, and also consider the quality assurance tools available to assist environmental monitoring laboratories concerned with the effective enforcement of the Water Framework Directive and its daughter directives.
- Work has also commenced on the development of a method to differentiate the ionic form of silver from the nanoparticulate form in the environment. Nanosilver is used as a bactericide in socks, and this can leach from the fabric during the washing process and will then be discharged into effluent streams. It has been shown that nanosilver can convert to the ionic form (Ag^{2+}) in the environment. Toxicological studies have shown that the ionic form of silver is significantly more toxic to the environment, but current methodology can only determine total silver, so the environmental load of toxic ionic silver can easily be overestimated. This small project aims to demonstrate that silver nanoparticles can be measured separately from silver ions so that environmental monitoring laboratories can get a much more accurate picture of the ionic silver load in effluent streams and water treatment plants in the UK.

Chemical nomenclature

The Government Chemist has been represented by Kevin Thurlow on the Advisory Committee to Chemical Nomenclature and Structure Representation Division (VIII) of the International Union of Pure and Applied Chemistry (IPAC) since its inception in 2002. Kevin has also represented the Government Chemist on the Royal Society of Chemistry (RSC's) "Committee on Standards in Nomenclature, Terminology, Units and Symbols" (CSN) since 1991.

The former committee is 'virtual'. Members are invited to comment on draft proposals and documents and to participate in drafting of new or revised recommendations for chemical nomenclature.

The RSC committee meets once a year. Most members are concerned with education (both school and university), but there are representatives of the British Standards Institute (BSI) and scientific societies. Government Chemist input is appreciated as it brings in an industrial and regulatory focus, more practical than theoretical, which is otherwise absent from the committee.

The LGC Forensic Drugs team assists the Ministry of Justice in the preparation of amendments to legislation. Our input to this consisted of supplying accurate chemical names and descriptions so that legislation could continue to deal with 'legal highs'. It is important that the correct chemicals or families of chemicals are banned, whilst allowing harmless chemicals, or legitimate medicines to be items of trade. Many of the 'legal highs' are chemically very similar to legitimate products, so care needs to be taken to ensure compounds with structural similarities to a banned product are not inadvertently caught under this developing area of legislation.

Substance identity is very important in compliance with legislation, particularly relating to chemical safety. REACH requires accurate naming of chemicals so that correct procedures can be followed to use chemicals safely, or to deal with problems efficiently if they occur. Kevin has also assisted with nomenclature for other legislation, and delivered a talk on the importance of nomenclature to chemical safety.

It is also important to use correct names in publications to aid communication. A paper reporting high-class research can be rendered worthless if it is not clear which chemicals are involved.

SCA Committees

The Government Chemist is also represented on the Steering Committee of the Standing Committee of Analysts (SCA). The SCA, sponsored by the Environment Agency, comprises a series of working groups who provide authoritative guidance on methods of sampling and analysis for determining the quality of environmental matrices. Guidance is published as Blue Books within the series "Methods for the Examination of Waters and Associated materials". During the year a member of staff was appointed Chairman and Co-ordinator of the Radiochemical Methods Working Group (WG9) of the SCA with a remit to review the current Blue Book radiochemical methods. Support was given to the Drinking Water Inspectorate in preparation of the UK's contribution to the development of a new European analytical standard, BS EN 15768:2015: Influence of materials on water intended for human consumption – GC-MS identification of water leachable organic substances.

Publications

Publishing peer reviewed papers is integral to our work enabling transparency to the analytical community. The following were published in 2014:

Walker M, Burns M and Thorburn Burns D, Horse meat in beef products, species substitution, 2013, Journal of the Association of Public Analysts (online), 2014, 41, 67-106

Walker M *et al*, A multi-laboratory evaluation of a clinically-validated incurred quality control material for analysis of allergens in food, Food Chemistry, 2014, 148, 30-36

Walker M, Thorburn Burns D and Deelstra H, The adulteration of food, lessons from the past, with reference to butter, margarine and fraud, Eur Food Res Tech, 2014, 239, 725-744

Walker M, Points J and Thorburn Burns D, Forensic issues in the analysis of trace nitrofuran veterinary residues, 2014, Journal of Food Control, 2014, 50, 92-103

Heroult J, Nischwitz V, Bartczak D and Goenaga-Infante H, The potential of asymmetric flow field-flow fractionation hyphenated to multiple detectors for the quantification and size estimation of silica nanoparticles in a food matrix, 2014, 406, 3919-3927

Hill S, Taylor A, Day M, Marshall J, Patriarca M and White M, Atomic spectrometry update: Clinical and biological materials, foods and beverages, Journal of Analytical Atomic Spectrometry, 2014, 29, 386-426

Wong Y-c, and Walker M, Achieving Quality Chemical Measurements in Foods, *In*: Rajeev Bhat, Vicente M. Gomez-Lopez (Eds) Practical Food Safety: Contemporary Issues and Future Directions, May 2014, Wiley-Blackwell, ISBN: 978-1-118-47460-0, pp 99 – 124

Walker M and Wong Y-c, Protection of the Agri-Food Chain by Chemical Analysis: The European Context, *In*: Rajeev Bhat, Vicente M. Gomez-Lopez (Eds) Practical Food Safety: Contemporary Issues and Future Directions, May 2014, Wiley-Blackwell, ISBN: 978-1-118-47460-0, pp 125 – 144

Gowland MH, Walker M, 2014, Food Allergy, a summary of 8 cases in the UK criminal and civil courts: effective last resort for vulnerable consumers?, Journal of the Science of Food & Agriculture, 2014 Nov 6. doi: 10.1002/jsfa.6988. [Epub ahead of print]

Gray K, Theodosis D, Mazur M, Minguez J, Cowen S, Elahi S and Walker M,Effect of Spiking Contact Times on the Analytical Recovery of Aflatoxins, Journal of the Association of Public Analysts (Online), 2014,42, 18-34

Busby E and Burns M, (2014), A Simple DNA-Based Screening Approach for the Detection of Crop Species in Processed Food Materials, Journal of the Association of Public Analysts, 2014, 42, 035-060. http://www.apajournal.org.uk/2014_0034-0060.pdf

Points, J, Thorburn Burns, D, Walker M, Forensic issues in the analysis of trace nitrofuran veterinary residues in food of animal origin, Food Control, 2014, 50, 92-103; First Available online 4 September 2014, ISSN 0956-7135, http://dx.doi.org/10.1016/j.foodcont.2014.08.037. (http://www.sciencedirect.com/science/article/pii/S0956713514004861)

Glossary

See the International Vocabulary of Metrology [51] for the current definitions of terms used in measurement science

AFM	Atomic force microscopy, a very high-resolution type of scanning probe microscopy
AMWG	Authenticity of Methods Working Group (Defra)
APA	Association of Public Analysts
BIS	Department for Business, Innovation and Skills
CLP	Classification, Labelling and Packaging Regulation
Defra	Department for Environment, Food and Rural Affairs
Derivatisation	Chemical modification of a substance, typically without changing its core structure, for example to facilitate measurement
DfT	Department for Transport
DH	Department of Health
DNA	Deoxyribonucleic acid
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
ELISA	Enzyme-linked Immunosorbent Assay
EU-RL	European Union Reference Laboratory
FBO	Food or feed business operator
FSA	Food Standards Agency
FSAI	Food Safety Authority of Ireland
FCM	Food Contact Material
GC-MS/MS	Gas chromatography-tandem mass spectrometry
GCWG	Government Chemist Working Group
GMO	Genetically Modified Organism
HPLC-ICP-MS	High performance liquid chromatography linked with inductively coupled plasma mass spectrometry
HSAC	Hazardous Substances Advisory Committee. Expert committee providing advice to Government on hazardous substances, toxicology, risk assessments.
IDMS	Isotope dilution mass spectrometry; a technique capable of outstanding accuracy
IFST	Institute of Food Science and Technology
IUPAC	International Union of Pure and Applied Chemistry
JAOAC	Journal of the Association of Official Analytical Chemists. A leading international journal for analytical measurement topics supporting legislation.
KF	Karl Fischer, an analytical technique for measuring water at low levels
LC-MS/MS	Liquid chromatography-tandem mass spectrometry
LOD	Limit of Detection
MChemA	Mastership in Chemical Analysis – this Royal Society of Chemistry qualification is required for appointment as a Public Analyst or as an Official Food Analyst
MRL	Maximum recommended level
NMI	National Measurement Institute
NMO	National Measurement Office
OIML	Organisation Internationale de Métrologie Légale (International Organization of Legal Metrology)

[51] International Bureau of Weights and Measures, International vocabulary of metrology – basic and general concepts and associated terms (VIM), Third Edition, JCGM 200:2008, 2008, www.bipm/org/utils/common/documents /jcgm/JCGM_200_2008.pdf

Glossary

Official Food Analyst	A person qualified under the Food Safety (Sampling and Qualifications) Regulations (1990 and/or 2013) (see also MChemA and Public Analyst)
PAH	Polynuclear aromatic hydrocarbon, a group of toxic chemicals
PCR	Polymerase chain reaction, a technique used to amplify DNA sequences so that they can be identified
Port Health Authority	Special type of local authority created to ease administration at seaports where the port area is covered by more than one local authority, responsible for carrying out checks on food and feed consignments
Public Analyst	Analytical scientist appointed under statute by UK local authorities to provide an official food or feed control function and scientific advice for the enforcement of many acts of Parliament
Quantitative analysis	Measurement, with results expressed as a number and a unit, of the quantity of a target substance in a sample, e.g. 10 mg/kg
RASFF	EU Rapid Alert System for Food and Feed
REACH	Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals, as amended
RSC	Royal Society of Chemistry
Referee analysis	Impartial analysis by the GC to help resolve disputes relating to test results obtained on behalf of two independent parties
Referee function	Duty of the Government Chemist under acts of Parliament to provide impartial analysis in the resolution of disputes relating to the enforcement of regulation
SEO	Supplementary expert opinion in the context of Regulation (EC) No 882/2004 on official controls, Article 11(5)
SS-IDMS	Species-specific isotope dilution mass spectrometry
Tandem mass spectrometry	use of linked mass spectrometers; molecules of interest can be broken up after the first stage to allow more detailed characterisation by analysing their fragments in the second
TGA-MS	Thermogravimetric analysis linked to mass spectrometry
UKCSF	United Kingdom Chemical Stakeholders Forum
UKAS	United Kingdom Accreditation Service
UV	Ultra-violet light
WFD	European Union Water Framework Directive

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