Institution: Queen's University Belfast

Unit of Assessment: UoA6

Title of case study:

From a crisis to the formation of an innovative food quality assurance scheme: The Food Fortress

Period when the underpinning research was undertaken:

2010-2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Professor Chris Elliott,	Professor	2006-present.
Professor Mark Mooney	Professor	2006-present.
Dr Simon Haughey	Senior Research Fellow	2008-present

Period when the claimed impact occurred: From 2014 – 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact

Economic significance: Towards the development of a food assurance scheme, Professors Elliott, Mooney and Dr Haughey developed, validated and implemented innovative techniques to detect and monitor a broad spectrum of feed-related contaminants. The resultant Food Fortress scheme was implemented in 2014 and by 2019, 5,000,000 tonnes of animal feed (Value: GBP1,250,000,000), supplied by 80 member companies were tested.

Industrial/Societal significance: The Food Fortress scheme is recognised internationally as a World-leading risk management and feed quality assurance scheme. Due to the Food Fortress brand and resultant increased confidence in food production, additional international dairy sales from Northern Ireland are estimated at GBP50,000,000 (2015–2019 data).

2. Underpinning research

Contamination of animal feedstuffs and the consequences for animal and human health are well recognised. The island of Ireland imports millions of tons of feed materials from across the world and as supply chains became more complex, this results in increased potential for accidental and intentional contamination. In addition, new feed safety issues continue to arise both from existing threats as seen with increases in natural toxin levels, such as mycotoxins, due to climate-related effects, but also from emerging diet-associated chemical contaminants e.g. pesticides or heavy metals.

Professors Elliott, Mooney and Dr Haughey and team have led and continue to lead an intensive research programme to develop, validate and implement innovative techniques to detect and monitor a broad spectrum of feed-related contaminants, which when incorporated within a risk-based sampling approach, provide a supply chain-wide quality assurance scheme. For example, the team published the use of laboratory-based spectroscopic techniques, coupled to chemometrics in 2013 and 2015 for rapid screening of feed adulteration in response to the 2008 melamine infant-milk scandal, which emerged in China and the United States **[3.1, 3.2]**. The scandal encompassed adulteration of infant formula milk with melamine to increase the nitrogen content of milk, but the resultant toxic effects resulted in 6 infant deaths and 54,000 babies being hospitalised. In order to detect melamine at low cost, Professor Elliott and Dr Haughey developed rapid and portable Near Infrared-based spectroscopic tools **[3.1, 3.2]**. Advances in the capability of mass spectrometry to detect feed-associated contaminants have also been exploited to develop a multi-mycotoxin analysis methodology **[3.3]**, which Northern Ireland feed industries and processing sectors rely on to determine mycotoxin risks since the publication of the method in 2015. This method is used routinely to investigative unexplained performance issues in the pig/poultry sectors.

Similarly, the dioxins food crisis in 2008, in which Irish pork were contaminated through their feed with this highly toxic chemical, resulted in Professors Elliott and Mooney developing low cost, high throughput metabolomic detection technologies**.** Development of dioxin detection technologies are, nonetheless, extremely difficult, costly and facilities for such analysis were previously limited. As a consequence, monitoring of feed samples for dioxins in the Irish Republic was previously only performed on a quarterly basis, Professors Elliott and Mooney undertook a series of experiments to identify biomarkers for animals exposed to dioxins and dioxin-like compounds that could be used to screen livestock **[3.4, 3.5]**.

Professor Elliott and team also undertook a detailed analysis of all feed contamination incidents globally over a 5-year period, within this REF cycle. From this they developed a 'Risk Register' for the animal feed industry, followed by development of the Food Fortress scheme **[5.2]**, allowing a 500% increase in testing performed for feed contaminants by industry. Specifically, research development underpinning the 'Food Fortress' scheme demonstrated high sensitivities, enabling sample compositing to be undertaken, which when coupled to a stratified sampling programme, allows for rigorous monitoring across the whole year. The Food Fortress scheme is based on a range of analytical techniques and tests developed within the Institute of Global Food Security, QUB based on animal feed safety and using innovative High Resolution Mass Spectrometry-based metabolomics as an 'early warning system' for farm animal exposure to dioxin contamination based on characterisation of key biomarkers of

exposures, and a suite of multi-analyte mass spectrometry screening assays for monitoring of an array of prioritised natural and man-made chemical toxins and contaminants **[3.6]**.

3. References to the research

3.1 Haughey SA, Graham SF, Cancouët E, Elliott CT. 2013. The application of Near-Infrared Reflectance Spectroscopy (NIRS) to detect melamine adulteration of soya bean meal., Food Chemistry, 136, 1557-1561.

3.2 Haughey SA, Galvin-King P, Malechaux, A, Elliott CT. 2015. The use of handheld near-infrared reflectance spectroscopy (NIRS) for the proximate analysis of poultry feed and to detect melamine adulteration of soya bean meal. Analytical Methods, 7, 1, 181-186.

3.3 Oplatowska-Stachowiak M, Haughey SA, Chevallier OP, Galvin-King P, Campbell K, Magowan E, Adam G, Berthiller F, Krska R, Elliott CT. 2015. Determination of the Mycotoxin Content in Distiller's Dried Grain with Solubles Using a Multianalyte UHPLC-MS/MS Method. Journal of Agricultural and Food Chemistry, 63 (43), pp. 9441-9451.

3.4 O'Kane A, Elliott CT, Mooney MH. 2014. Complex Interactions between Dioxin-Like and Non-Dioxin-Like Compounds for in Vitro Cellular Responses: Implications for the Identification of Dioxin Exposure Biomarkers. Chemical Research in Toxicology, 27(2), 178-187.

3.5 O'Kane AA, Chevallier OP, Graham SF, Elliott CT, Mooney MH. 2013. Metabolomic profiling of in vivo plasma responses to dioxin-associated dietary contaminant exposure in rats: implications for identification of sources of animal and human exposure. Environmental Science and Technology, 47(10), 5409-18.

3.6 de Jong J, López P, Mol H, Baeten V, Fernández Pierna JA, Vermeulen P, Vincent U, Boix A, von Holst C, Tomaniova M, Hajslova J, Yang Z, Han L, MacDonald S, Haughey SA, Elliott CT. 2016. Analytical strategies for the early quality and safety assurance in the global feed chain. Approaches for nitrogen adulterants in soybean meal and mineral and transformer oils in vegetable oils. Trends in Analytical Chemistry, 76, 203-215.

4. Details of the impact

Development of the ‘Food Fortress’ scheme ensued largely in response to the 2008 dioxin crisis on the island of Ireland, during which a total of approximately 30,000 tonnes of pig meat product was recalled and destroyed (including 5,000 tonnes outside Ireland) due to ingestion of feed with high levels of the highly toxic chemicals **[5.1]**. Additionally, over 170,000 pigs and 5,700 cattle from farms that received contaminated product were culled on a precautionary basis. The dioxin crisis fraud in the animal feed sector was found to be caused by a single small business, whereby a small quantity of highly toxic dioxin and poly-chlorinated biphenyl

chemical compounds from contaminated transformer oil made its way into the animal feed supply chain and subsequently into pig fat deposits. The contamination was eventually detected by the national monitoring programme leading to multiple farm closures, major animal welfare issues and a global recall of Irish pork, resulting in the loss of an estimated 1,800 jobs. The incident was estimated to have cost the economy of island of Ireland over EUR120,000,000 **[5.1]** and resulted in a highly damaging conflict between regulatory agencies and food industries and a suit of recommendations to avoid such instances in the future **[5.2]**.

Professor Elliott and team were approached by the feed sector to identify ways of preventing the occurrence of such catastrophic feed-related contamination in the future. A programme was devised, called Food Fortress, that increased the level of testing for all high-risk chemical contaminants by over 500% without any additional industrial costs. The Food Fortress scheme was launched by QUB as a pilot in 2014 with 19 large animal feed companies involved. Membership to the scheme is voluntary with an annual fee, but the benefits in terms of consumer confidence outweigh the costs as demonstrated by the growth of the pilot towards adoption by all animal feed companies in Northern Ireland by 2016, and by August 2019 the Food Fortress membership has risen to over 80 with companies recruited from the Republic of Ireland and the United Kingdom **[5.3]**. From a position of crisis, the Food Fortress scheme is now used as a major marketing tool by the UK and Republic Ireland food industries, with new markets in South East Asia having been secured due to this world leading feed contamination risk management system being in place **[5.4]**. Food Fortress has been presented to over 120 buyers on inward missions from 20 Middle East and Asian countries. As a direct result the NI dairy sector has reported additional sales in the region of GBP50,000,000 in the first 4 years of operation of the Food Fortress scheme **[5.4].**

Dairy council testimonial **[5.4]:**
'The success of these programs can be seen in buyer attitudes and increased sales. The most recent trade fair attended was Food Ingredients China, held in Shanghai in March 2019. Evaluation showed that 100% of buyers who visited the stand were impressed and 100% stated their confidence and trust in NI dairy products had increased. In terms of sales, by end of year 6...it is estimated these programmes will have delivered additional sales around £50 million.'

This highly novel approach to contaminant monitoring and the acceptance of such techniques by the feed industries on the island of Ireland is a clear indication of the trust and reliance that has grown between the QUB academics and the feed industry **[5.5]**.

Food Standards agency testimonial **[5.5]:**

'In 2019, the Northern Ireland Grain Trade Association outlined the work of Food Fortress to the FSA's NI Food Advisory Committee (NIFAC) chaired by the FSA's NI Board Member. The committee commended the Food Fortress scheme as a great example of industry-led assurance done properly, noting that a substantial number of businesses from the Republic of Ireland were also engaged in the scheme in addition to those from NI'.

However, testing methods, no matter how quick and reliable, need to be sufficient to deal with the magnitude of the challenges presented in monitoring many millions of tonnes of feed materials each year. This testing must be embedded within a risk-based sampling approach, based on a sample compositing and analysis strategy. This is very much how the Food Fortress is structured and each year the Institute for Global Food Security updates this sampling and testing scheme based on risks identified, and by introducing new approaches to speed up the programme of testing whilst maintaining cost-effectiveness. The testing scheme undertaken by Food Fortress has been approved by both the Department of Agriculture for Northern Ireland and The Food Standards Agency (NI) [**5.6** outlines the details of the farm quality assurance scheme underpinned by feed approved from food fortress, and **5.7** outlines the agreement in place to share data from Food Fortress to the Department of Agriculture for Northern Ireland and The Food Standards Agency (NI)]. The Livestock and Meat Commission for Northern Ireland is an Executive Non-Departmental Public Body and their regulations include all farms in NI under their control purchase feed from members of the Food Fortress **[5.6, 5.7]**.

5. Sources to corroborate the impact

5.1 Marnane, I. 2012. Comprehensive environmental review following the pork PCB/dioxin contamination incident in Ireland. Journal Environmental Monitoring. 14(10):2551-6.

5.2 Dioxin enquiry and compensation report (PDF).

5.3 http://www.foodfortress.co.uk/ (PDF).

5.4 Testimonial from NI Dairy Council requested giving Inventory of buyers from Middle East and Asian countries on inward trade missions and value of additional exports due to Food Fortress (PDF).

5.5 Testimonial from the Food Standards Agency evidencing the commendation of the food fortress scheme (PDF).

5.6 Farm Quality Assurance Scheme – Standards and Rules (PDF)

5.7 Food Fortress: Information Exchange Protocol with Department of Agriculture, Environment & Rural Affairs and Food Standards Agency (PDF).