Food Hazard alert:

Development of a pilot risk register for the pig and poultry meat sectors on the island of Ireland:

A Technology Viability Study

be safe be healthy be well

Food hazard alert: Development of a pilot risk register for the pig and poultry meat sectors on the island of Ireland

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Acknowledgements

This is a technical report of a research project funded by ***safe*food** to investigate the feasibility of establishing a Risk Register for the pork and poultry industries on the island of Ireland. These are major employers and export large quantities of products. The goal of the research is ultimately to augment the resilience of both industries in terms of the quality and safety of their products. Due to complex and global nature of supply chains, there will always be potential risks arising from chemical or microbiological contamination, and while some of these risks are already known, there is always a possibility of an unknown hazard impacting on the food chain. A Risk Register would go some way toward providing an early warning system to guard against such impacts. The research was undertaken by Prof Chris Elliott, Director of the Institute for Global Food Security at Queen's University Belfast and his team of researchers, in particular Dr Julie Meneely, Dr Simon Haughey, Dr Michelle Spence and Dr Moira Dean. Prof Francis Butler and Dr Gráinne Redmond of the School of Biosystems Engineering in University College Dublin, and Dr Martin Danaher, Teagasc-Ashtown Food Research Centre were the prinicpal collaborators on this project. ***safe*food** would like to thank all the researchers involved in this project.

Executive Summary

The pork and poultry industries on the island of Ireland (ioI) are major employers and export large quantities of product. The quality and safety of these products is of paramount importance. Any issues in relation to either parameter can cause significant reputational damage, not only to the company involved, but the entire industry, public health impacts notwithstanding. Due to complex supply chains there will always be potential risks arising from chemical and microbiological contamination, and while some of these risks are already known, there is always a possibility of an unanticipated contamination of a food supply occurring which may result in financial and reputational losses due to the integrated nature of the industry. Contamination and adulteration of food products is increasingly reported in the media, often causing public concern and possibly a loss of faith in food producers.

A novel risk ranking framework was developed to rank the risk of pathogens in Irish produced poultry meat based on the combination of the occurrence of these pathogens in poultry meat together with severity of disease associated with the pathogen. A systematic review of the literature and publicly available data was undertaken to collect data regarding the occurrence of selected pathogens on Irish produced poultry meat. These were categorize for pathogenicity based on the International Commission on Microbiological Specifications for Foods (ICMSF) classification and an estimate of the risk from each pathogen was produced. As expected, *Campylobacter* spp. emerged as the pathogen of most concern in poultry produced on the ioI given its high occurrence.

A comprehensive review of residue data sets for poultry and pork meat was carried out from different sources including Irish, EU and third country imports. Irish data was extensive and covered years from 1998 and 2014 (Republic of Ireland) and 2004 to 2014 (Northern Ireland) data. EU data was only available for the years 2008 to 2012. Data for residues in imported meat samples into the EU covered the years 2002 to 2015. In general, it was found that the residue risk was largely dependent on the source of the meat products. This is particularly the case with meat imported from outside of the EU because some drugs are used in these countries that are not licensed in the EU and thus have no EU maximum residues limits. In addition, a limited number of other drugs may be available in non-EU countries that are banned within the EU, such as the nitrofurans and nitromidazoles. In either situation, if a measureable level of either residue is detected in official border inspection post (BIP) samples, RASFF notifications will be issued. This will lead to the implementation of safeguard or reinforced checks at the BIPs. In recent years, there have been a number of examples of these reinforced checks for anticoccidial residues in poultry, namely for clopidol, toltrazuril and cyromazine.

The net impact of these enforcement actions is huge financial losses due to rejection of import consignments or hold-up at Border Inspection Posts. There have been fewer such notifications or rejections for pork in recent years.

A risk prioritisation exercise was carried out for poultry, which identified the most important residues for the sector. These include antibacterial agents, anticoccidial and some banned veterinary drugs (chloramphenicol, nitrofurans and nitroimidazoles). The most important substances for the pork sector were steroids (in particular nandrolone), dioxins, banned veterinary drugs and licensed antibacterial agents. Sedatives/tranquilisers and quinoxalines were also identified as contentious residues for the pork sector. Approaches were also proposed for compositing of samples to allow industry to reduce residue testing costs. This included examples of where the composting approach could be applied effectively.

A range of advanced residue methods were applied to analyse residues in meat samples including methods for anticoccidials and beta-lactam residues. The results of these analyses showed that all of the tested samples were compliant. A high incidence of anticoccidial residues were detected in imported chicken with 25 of 54 samples containing residues but all were well below EU maximum residue limits.

The project also analysed the risk from different food ingredients in pork and poultry products. Using the EU Rapid Alerts System (RASFF), data relating to all notifications was analysed based on the types of food commodities, the reasons for notifications and the geographic source of the alert. Each alert was subjected to further analysis based on the risk of consumption by humans and scored accordingly thus ranking the testing priorities for a given commodity in terms of primary, secondary, tertiary risk etc. Therefore, for each type of food material imported into the country, an accurate picture of the contaminants that are most likely to be found, the origin of the material and the risk of this contamination entering the food supply chain can be assessed.

The participation from the poultry and pork industry on the ioI was sought and seven companies agreed to engage in the project. Questionnaires were sent to each participant to collect detailed information relating to the ingredients used for products, testing regimes, control systems in place, demographics and perception of hazards. The food commodities were divided into the following categories; alcoholic beverages, cereals, eggs, fats and oils, food additives and flavourings, fruits and vegetables, herbs, spices, honey, meats and meat products (other than poultry), milk and milk products, non-alcoholic beverages, peanuts and tree nuts, oilseeds and other seeds (excluding oil), other food products, poultry meat and poultry meat products, soups, broths, sauces and condiments and water. The hazards associated with these ingredients were categorised as follows: industrial contaminants, heavy metals, prohibited veterinary products, total (mycotoxins & biotoxins), unauthorised pesticides, unauthorised veterinary products, pathogenic micro-organisms, approved pesticides, parasitic infestation, allergens, legal veterinary products, food additives and flavourings, composition and non pathogenic micro-organisms.

The results revealed that the primary risk for many raw materials used on the ioI was from pathogenic micro-organisms, followed by mycotoxins/biotoxins, food additives and flavourings, industrial contaminants, veterinary drug residues (prohibited and unauthorised) and pesticides (banned or unauthorised). Other risks associated with food commodities that could not be scored included adulteration/fraud, chemical contamination (other), foreign bodies, GMO & novel foods and absent/incomplete/incorrect labelling.

Trend analysis from 2009-2013 and 2010-2014 indicated increases in the number of notifications relating to approved pesticides, heavy metals, pathogens and legal veterinary medicines, and those for parasitic infestation, mycotoxins, allergens, composition, unauthorised veterinary medicines, industrial contaminants and non-pathogenic micro-organisms fell during that time. In terms of commodity notifications, increases were observed for non-alcoholic beverages, food additives and flavourings, milk and milk products, fruit and vegetables, poultry meat and poultry meat products, meat and meat products (other than poultry), cereals and spices. There were fewer alerts for honey, oilseeds and other seeds, soups, broths sauces and condiments, peanuts and tree nuts, water, eggs and herbs.

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1 Introduction

The pork and poultry industry on the ioI are major employers and export large quantities of products. The quality and safety of these products is of paramount importance and any issues in relation to either parameter can cause significant reputational damage, not only to the company involved but the entire industry.

Due to complex supply chains there will always be potential risks arising from chemical and microbiological contamination. While some of these risks are already known there is always a possibility that an unanticipated contamination of a food supply may occur resulting in enormous economic loss due to the integrated nature of the industry. While all companies try to manage these risks as best as they can, the scale of the task is immense and needs to be addressed on an industry wide scale.

Risk is generally considered to be a combination of the exposure to and the severity of a hazard. Ranking hazards that are likely to occur in the food chain is a key step in driving risk management actions and in prioritising resources for control of the hazards of most concern. Risk ranking has been recognized as the appropriate starting point for risk-based priority setting and resource allocation, because it permits policy makers to focus attention on the most significant public health problems and develop strategies for addressing them. In a risk-based system, resources for food safety should be deployed in a manner that maximizes the public health benefit achieved through risk reduction [1]. The concept of the Risk Register has already been developed and applied to animal feed which has directly led to the set up and successful implementation of the Food Fortress concept (http://www.foodfortress.co.uk/). The objective of this research was to develop a Risk Register based on the analysis of data from both public and private sources. The core objectives of the project were:-

Objective 1: To develop a risk ranking model that industry could use to rank potential bacterial hazards present in poultry.

Objective 2: To analyse residue occurrence data for pork and poultry samples collected as part of national residue surveillance schemes in Ireland and across the EU.

Objective 3: To develop a Risk Register based on the analysis of both publicly avilable and confidential data from a wide range of existing sources.

2 Project aims and objectives

Objective 1

To develop a risk ranking model that industry could use to rank potential bacterial hazards present in poultry. To demonstrate the approach, a risk ranking of bacterial hazards present in poultry produced on the ioI was undertaken. This was carried out using occurrence data available in the public domain for poultry produced on the island of Ireland. As a comparison, an additional study was carried out for poultry produced by a country exporting significant quantities of poultry to the island of Ireland. Two broad approaches for risk ranking of microbiological hazards were identified previously [2]. The first approach is using epidemiological data where sufficient source attribution data is available to rank pathogen/hazard combinations. The second approach uses principles of food safety risk assessment which couple the probability of exposure to a hazard, the magnitude of the hazard in a food when present and the probability and severity of the outcomes that might arise. In 1998, the FAO presented a two dimensional risk assessment grid in which the axes for the grid are likelihood of occurrence of the hazard and the severity of the disease outcome [3]. The risk ranking model developed in this study is based on this FAO grid, however the likelihood of occurrence is replaced by a semi-quantitative estimation of the occurrence of the pathogen in raw poultry.

Objective 2

To analyse residue occurrence data for pork and poultry samples collected as part of national residue surveillance schemes in Ireland and across the EU. Extensive datasets are available for Ireland covering the periods 1998 to 2014 through Irelands National Food Residue Database and through datasets published on the Irish Department of Agriculture Food and the Marine [4-7]. Northern Ireland datasets were accessed through the Agri-food and Bioscience's Institute website [8-18]. In contrast, results for EU wide residue testing are only available for the years 2008 to 2012 [19-23]. The results for residues in pork and poultry imported from outside of the EU have been obtained from RASFF reports for the years 2002 to 2015. The scope of the report covers both Group A (banned drugs and illegal growth promoting agents) and Group B (licensed veterinary drugs) substances outlined in Table 1. It is highlighted that occurrence data for residues in pork and poultry tissue samples has changed greatly over time due to a number of factors including:

- Sensitivity of the analytical test methods used.

- Range of substances included in analytical test methods.
- Differences in licensing/authorisation of veterinary medicinal products or feed additives in different countries.
- Changes in legislation in relation to the maximum residue limits for residues.

It is acknowledged that there has been a significant improvement in residue surveillance since mid-2000s, largely due to the widespread implementation of LC-MS/MS (liquid chromatography coupled to tandem mass spectrometry) in residue surveillance laboratories. As a result, the scopes of analytical methods have greatly improved in terms of substance coverage and sensitivity. However, residue data needs to be carefully interpreted because of differences in test methods between countries in the EU.

Table 1: Substance coverage for foods of animal origin as outlined in Directive 96/23/EC

Group	Substance Group	*Function*
	Group A: ***Banned substances***	
A1	Stilbenes, stilbene derivatives, and their salts and esters	Growth promotion
A2	Antithyroid agents	Thyroid hormone antagonists
A3	Steroids	Growth promotion
A4	Resorcylic acid lactones including zeranol	Growth promotion and non-steroidal oestrogen agonists
A5	Beta-agonists	Lipid metabolism and muscle growth
A6	Prohibited substances under table 2 of the Regulation 37/2010 for which MRL could not be established	Pharmacologically active substances
	Group B1&2: ***Licensed veterinary drugs***	
B1	Antibacterial substances	Antibacterials
B2a	Anthelmintics	Antiparasitic compounds
B2b	Anticoccidials, including nitroimidazoles	Antiparasitic compounds
B2c	Carbamates and Pyrethroids	Insecticides
B2d	Sedatives	Tranquillisers
B2e	NSAIDs	Non-steroidal anti-inflammatories
B2f	Other pharmacologically active substances	Pharmacologically active substances
	Group B3: ***Other substances and environmental contaminants***	
B3a	Organochlorine compounds including PCBs	Insecticides
B3b	Organophosphorus compounds	Insecticides
B3c	Chemical elements	Eg. Lead
B3d	Mycotoxins	Fungal toxins
B3e	Dyes	Natural and man-made
B3f	Other substances	

Objective 3

To develop a Risk Register based on analysing data from a wide range of existing sources, some in the public domain and some confidential. On a strictly confidential basis, companies provided details of their raw materials/food ingredients and testing regimes. The raw material/food ingredient data was coupled to data in the public domain (EU Rapid Alerts System) and an analysis of information available from EFSA on emerging risks and the ingredients scored based on 'frequency of hazard occurrence' x 'hazard severity score' [24]. Based on these results, recommendations as to what testing should be implemented was reported back to the industry. Seven companies, five from Northern Ireland and two from the Republic of Ireland agreed to take part in the project. These included the major pork/poultry companies on the IoI. The participants completed a questionnaire detailing the company demographics; control systems in place; choice of raw materials, food ingredients and ingredient suppliers and monitoring and perception of hazards.

3 Objective 1

Microbiological contaminant risk prioritisation for poultry

Risk ranking model development

Hazard identification

For this study, four bacterial pathogens were considered – *Salmonella* spp., *Campylobacter* spp, VTEC and *Listeria monocytogenes*. These four pathogens were considered as previous work has identified them as major pathogens of concern in poultry [25]. Other pathogens could be considered; however, for this initial risk ranking framework development work, the analysis was confined to the four pathogens mentioned above. Potentially, there is no restriction on the number of pathogens that could be considered if the necessary data is available. However, the quantity of data available in the public domain in relation to the occurrence of these four pathogens in poultry produced on the ioI varied significantly depending on the pathogen in question.

Table 2: Ranking of the foodborne pathogens associated with poultry considered in this study into hazard groups

Pathogen	ICMSF Category
Enterohemorrhagic *E. coli* (e.g. Verotoxigenic *E. coli* O157:H7)	I.A Severe hazard for general population, life threatening or substantial chronic sequelae or long duration
Campylobacter jejuni *Listeria monocytogenes*	I.B Severe hazards for restricted populations, life threatening or substantial chronic sequel or long duration
Salmonella spp. *Listeria monocytogenes*	II. Serious hazard: incapacitating but not life threatening, sequealae infrequent, moderate duration.

Model development

A simple risk ranking model was developed based on the two-dimensional risk assessment grid developed by the FAO [3]. The FAO approach is based on the concept of risk as a combination of the probability of exposure and the severity of the hazard. In this two-dimensional risk assessment grid, the axes for the grid are likelihood of occurrence of the hazard and the severity of the disease outcome. For this work, the FAO two-dimensional risk assessment grid was modified so that the horizontal axis represented the severity of the microbial pathogens generally associated with poultry. In 1986, the International Commission of Microbial Standards for Foods (ICMSF) concluded that food-borne pathogens should be grouped into categories base on severity. This was updated in 2002 and Table 2 shows the pathogens associated with poultry categorized according to the ICMSF criteria [26]. This severity categorisation represents a robust characterisation of the pathogens associated with poultry in accordance with internationally recognised criteria. This severity characterisation can then be used on the severity of consequences axis of the FAO Risk Assessment grid.

The ICMSF classification provides a basis to categorize the severity of pathogens. Information is then required on the likelihood of occurrence to allow a mapping of the pathogens on the FAO risk assessment grid. Ideally likelihood of occurrence should be measured at point of consumption; however in practice this type of data is not available. The typical data that is available is occurrence data for the pathogens at slaughter house or at retail level. For a raw poultry carcass intended for cooking by the consumer before consumption, the final cooking step in the home represents the final elimination of pathogens before consumption. For any of the potential pathogens associated with poultry, illness may occur if there is undercooking of contaminated poultry, or cross contamination of other food products by raw contaminated meat. Accurate surveillance of the magnitude of the incidence of food-borne illness due to these pathogens continues to be a challenge although underreporting estimates are now available for the most common pathogens [27]. Irrespective of the pathogen, the higher the occurrence of the pathogen on the raw carcass, the higher will be the likelihood of illness in the event that undercooking or a cross contamination event occurs. Accordingly, occurrence data for the pathogen on poultry in the slaughter plant gives some measure (albeit an approximate one) of the likelihood of occurrence of the pathogen for the purposes of the risk ranking grid.

Data sources

A systematic review of the literature using data sources in the public domain was undertaken for occurrence of pathogens in poultry produced on the island of Ireland. As indicated in Table 2, four bacterial pathogens were considered – *Salmonella spp.*, *Campylobacter spp.*, enterohemorrhagic *E. coli* and *Listeria monocytogenes*. Data on the pathogen, the year when the study was conducted, the stage in the process chain where the sample was taken, the sample size and the number of positives was recorded. This exercise was repeated for a second country which is a major producer of poultry and which exports large amounts of poultry to Ireland.

Research findings

Rather than use a single point mean estimate of the occurrence data gathered for each of the pathogens, the occurrence data in poultry for each of the pathogens was summarized into time series plots to give an indication of the variation with time in the occurrence of the pathogen and also an indication of the amount of data collected.

Figure 1 gives an example of a time series plot for the data collected for the occurrence of *Campylobacter* spp. in Irish poultry. Data from over twenty studies between 1993 and 2012 was available. As the time series plot shows, there was a significant variation in the occurrence of *Campylobacter* reported. On the right hand side of the time series plot, a box plot is presented summarizing the distribution in the occurrence data reported in the time series plot. The box plot indicates the first quartile (the middle number between the smallest number and the median of the data set) and the third quartile as the bottom and top of the box. The band inside the box is the median. The lower whisker represents the lowest datum still within 1.5 times the interquartile range below the lower quartile. The upper whisker represents the highest datum still within 1.5 times the interquartile range above the upper quartile. Any data points outside the whiskers are individually plotted as outliers. The box plot gives a summary of the distribution in the occurrence reported in the time series plot. From a risk management perspective, they give a convenient graphical representation of the distribution in the reported occurrence for a given pathogen taken from different studies.

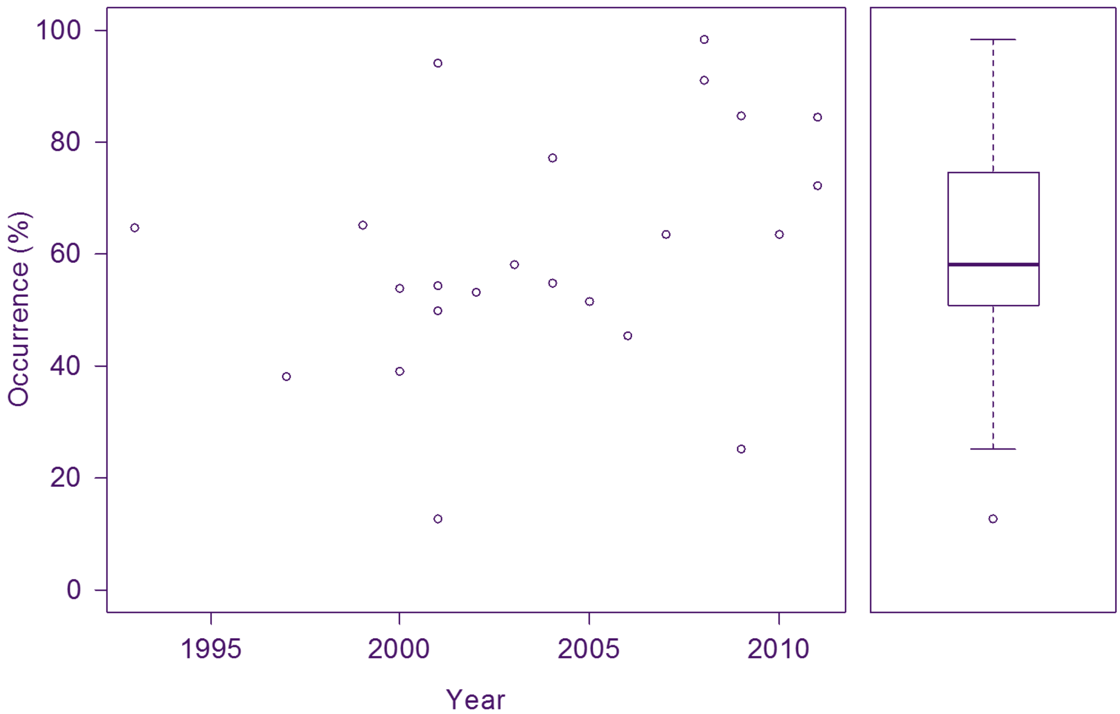


Figure 1. An example of a time series plot of occurrence of *Campylobacter* spp. in poultry

To complete the risk ranking framework, the FAO two-dimensional risk assessment grid was modified so that the horizontal axis represents the severity of the microbial pathogens associated with poultry ranked according to their ICMSF classification. Likelihood of occurrence of the hazard was represented on the vertical axis by the box plots for the individual pathogens which were superimposed directly on the grid to give some measure of the variability in the reported occurrence of the four pathogens considered.

The two dimensional risk ranking grid shown in Figure 2 summarises all of the data collected on the microbial pathogens identified for poultry produced on the island of Ireland. *Campylobacter* spp. emerges as the pathogen of most concern in Irish produced poultry. *Campylobacter* is classified as a Category IB pathogen in the ICMSF severity classification of microbial pathogens. There is considerable Irish surveillance data collected that would indicate the prevalence for *Campylobacter* is between 23 and 98%.

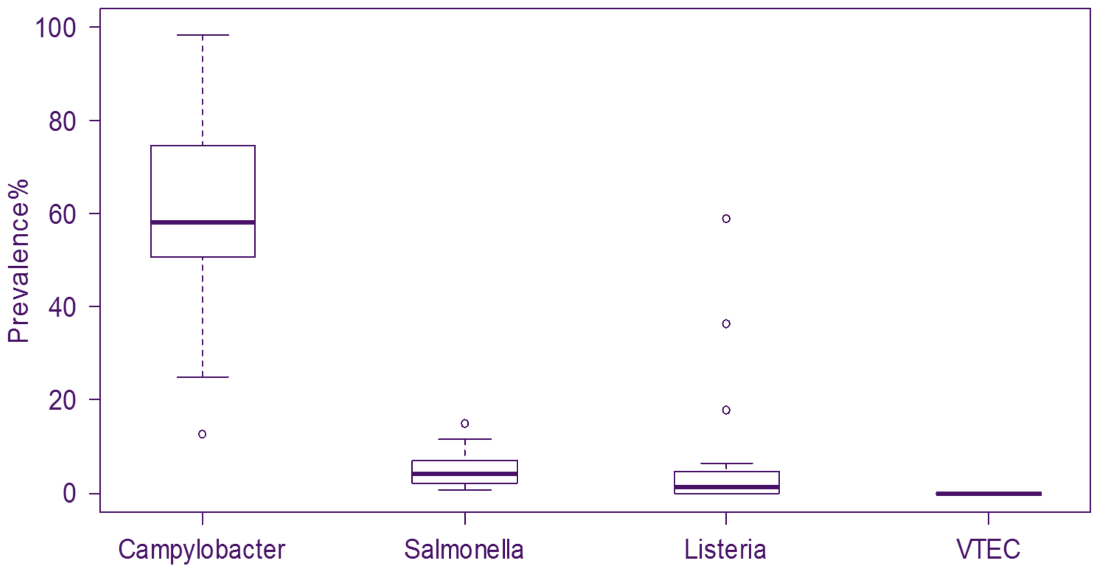


Figure 2: Two dimensional risk ranking framework for microbial pathogens in poultry produced in the island of Ireland

The risk ranking exercise was repeated for a second non-EU country which is a major producer of poultry and which exports large amounts of poultry to Ireland. Figure 3 summarises the two dimensional risk ranking framework for the same four pathogens for poultry produced in that country. A comparison between Figure 2 and 3 indicates the relatively higher occurrence of *Salmonella* and *Listeria monocytogenes* in the poultry produced in that country in comparison to Irish produced poultry. For a processor using imported poultry from that country, the risk ranking framework would demonstrate that the potential risks associated with using poultry from that source could be quite different to poultry sourced from the island of Ireland.

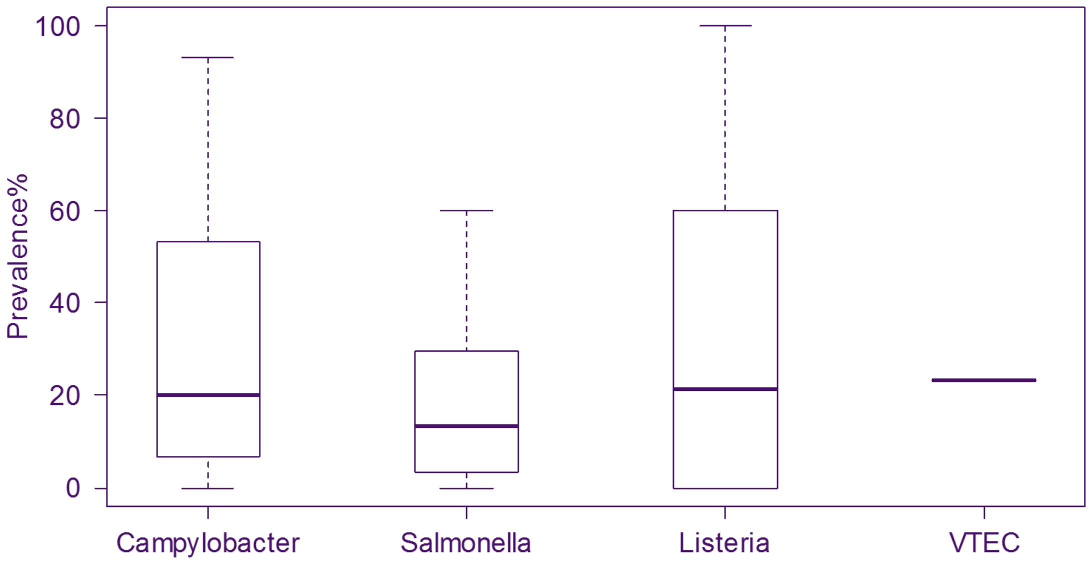


Figure 3: Two dimensional risk ranking framework for microbial pathogens in poultry produced in a major poultry export country

Discussion

The risk ranking model developed in this study is relatively straightforward to construct but gives a succinct summary to risk managers as to the nature of the hazards present and how those hazards may change depending on the origin of the product. The utility of the ranking model is only as good as the availability of the data that underpins the model. The current study used occurrence data that was available in the public domain. Ideally, a company would supplement this with their own data to develop the risk ranking framework. The novel combinations of the box plot representation of the prevalence data together with the severity of the consequences for each of the pathogens, presents a useful graphical representation of the risk ranking that can then be interpreted by risk managers. As such, this representation is a considerable improvement on the simple two dimensional FAO health risk assessment model [3].

This study reported occurrence of individual pathogens, generally measured at or close to the slaughter stage in the overall distribution chain as a measure of likelihood of occurrence of illness. Clearly this is only a proxy measurement of likelihood of illness occurrence. The pathogens do not have similar probabilities of survival or a similar ability to cause illness in, for example, undercooked product. Survival/growth characteristics at different temperatures is different for the four pathogens. However, the basic assumption is valid, that for raw meat products, the distribution chain can be considered a pipeline, and the higher the prevalence of the pathogen at the start of the pipeline, there is a greater chance of illness occurring at the end of the chain when the product is consumed, arising from undercooking, cross contamination etc., irrespective of the pathogen. From a regulatory agency perspective, if risk management actions can be taken to reduce the percentage of product that is contaminated with a pathogen, then there is a reasonable expectation that the burden of illness arising from food poisoning from these products will reduce.

Availability of good data is critical in the development of the risk ranking framework. Significant data gaps emerged in relation to the number of studies that were available in the public domain relating to the occurrence of certain pathogens, particularly in relation to VTEC. One advantage of the time series plots is that it is immediately obvious how many studies are available for a particular pathogen and action can be taken to undertaken further surveillance if necessary.

It was not the intention that this risk ranking approach should give a numerical ranking of pathogens in poultry as other risk ranking methodologies have attempted (for example, RiskRanger) [28]. Rather, it was the intention to develop a risk ranking tool that gives risk managers a rapid, primarily visual, oversight of the main microbial hazards of importance in poultry products. This will assist in making appropriate risk management decisions in terms of increased surveillance of specific pathogens in certain products.

4 Objective 2

Residue Risk Prioritisation for the Pork and Poultry Meat Sectors

Analysis of residue occurrence data for poultry

Group A substances

An overview of non-compliant results for group A substances in poultry samples collected in the Republic of Ireland between 1998 and 2014 are presented in Figure 4. Only one non-compliant sample was observed for group A substances in 2011. The one non-compliant for beta-agonists in 2011, was a sample containing isoxsuprine at a level of 0.16 μg/kg. Follow-up investigations did not reveal any evidence of illegal administration. The results from samples analysed as part of the Northern Ireland National Plan were interrogated for the years 2004 to 2014. In 2004, 21 out of 635 samples were found to be non-compliant for the banned veterinary drug furazolidone. On-farm investigations, found furazolidone-containing sediments at the bottom of these farms' older-style water tanks [8]. It was thought that the sediment was inadvertently stirred up during a recent change in the tank cleaning procedure. Prior to being banned, this drug would have been administered via the drinking water. The company programmed the replacement of the older, potentially contaminated tanks; results for November and December 2004 samples were compliant and were allowed into the food chain. Only one other non-compliant result was found during this time period, which was a single sample found to contain low levels of metronidazole in 2005 [9].

It can be seen that the overall rate of non-compliance for group A substances has been very low in Irish poultry meat samples. However, the furazolidone incident in 2004, highlights the need for on-going monitoring of these substances. The occurrence of group A substances in food samples at any levels can have serious consequences for the food industry, including product recalls.

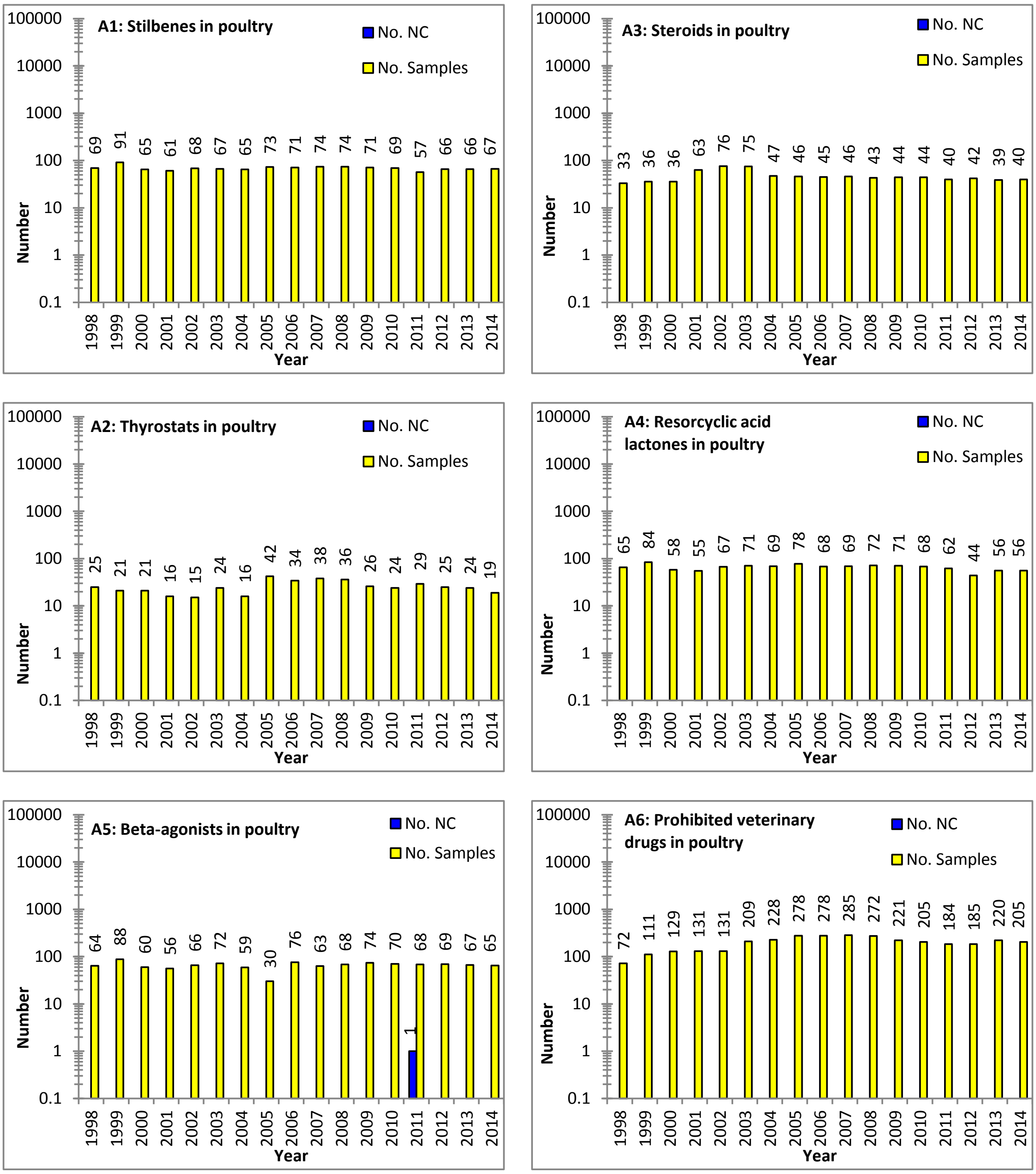


Figure 4: Results for the monitoring of Group A substances in poultry samples collected in the Republic of Ireland between 1998 and 2014. Yellow and blue bars denote number of samples analysed and non-compliant (NC) results, respectively.

The EU wide monitoring of residues in poultry show that Group A substances were only found in a very low number of samples. Group A3 (steroids) and A5 (beta-agonists) were the only growth promoting substances found in poultry in the years 2008 and 2012 (Figure 5). The group A6 prohibited veterinary drugs, which include chloramphenicol, nitrofurans and nitroimidazoles were the most frequently detected group A substances (rate of positives = 0.04%).

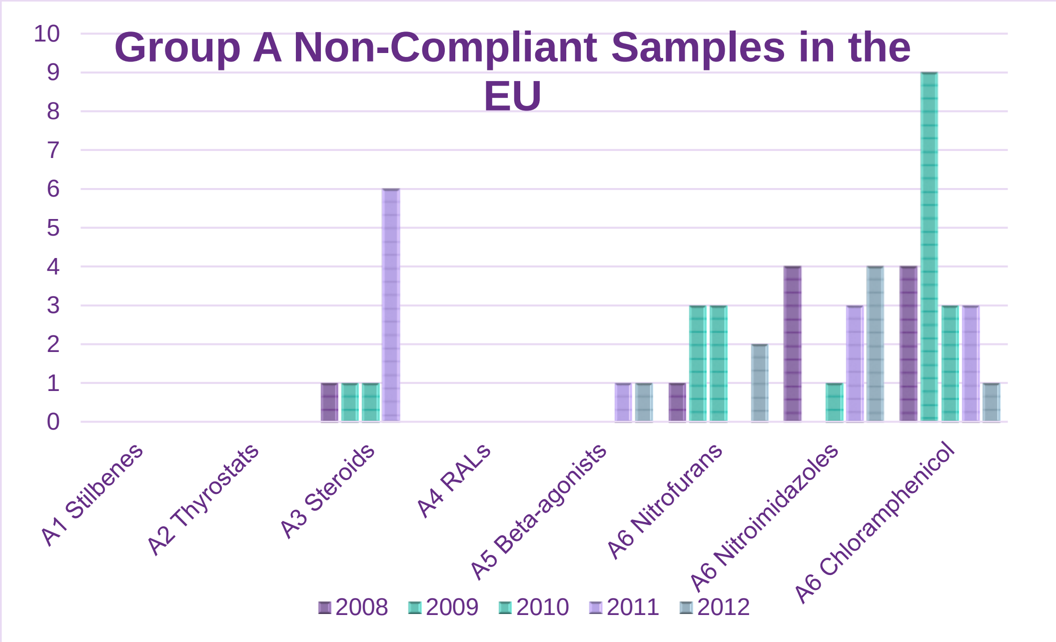


Figure 5: Overview of EU wide positives for Group A substances in poultry

Results from monitoring of Group A substances in poultry imported from outside of the EU are presented in Figure 6. In 2002 and 2003, there were a large number of non-compliant results in poultry meat at the height of the nitrofuran incident, 88 and 55 non-compliant reports, respectively. It can be seen that since the rate of non-compliant results for Group A substances in imported poultry tested in the EU has dropped dramatically. No non-compliant samples have been found since 2009.

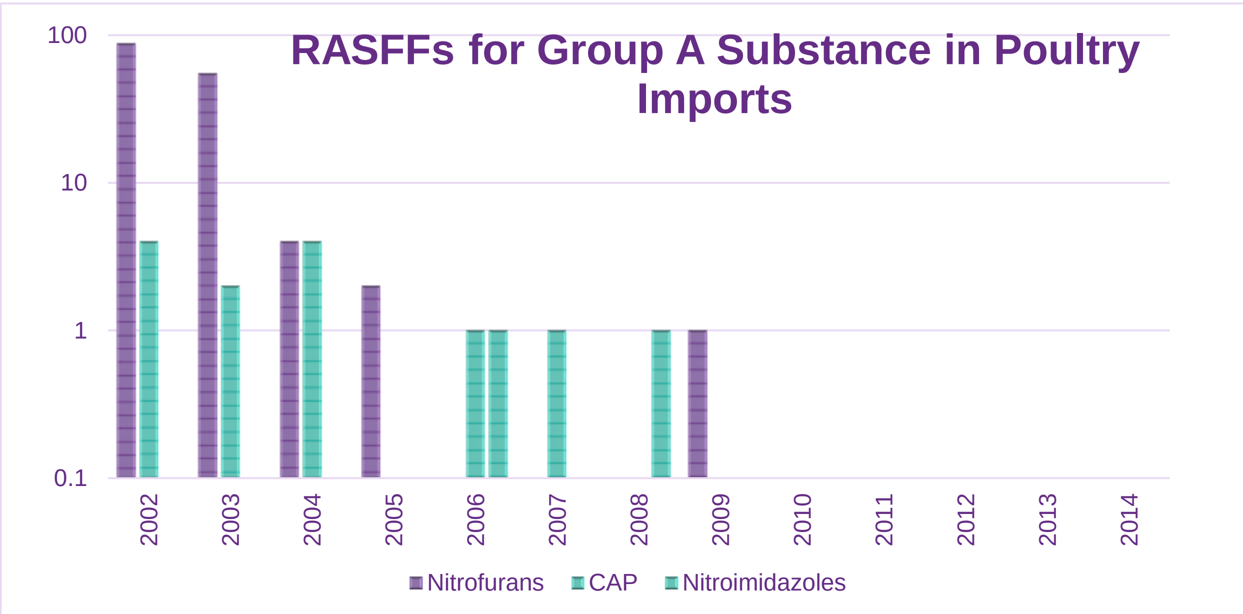


Figure 6: Non-compliant results for Group A substances in poultry imported into the EU between 2002 and 2014

Group B substances

This group comprises (a) pharmaceutically active substances that are administered to food producing animal species, and (b) chemical contaminants. These compounds are more frequently detected in food compared to Group A substances because of their use in maintaining animal health.

The anticoccidials have been the most frequently reported non-compliant residues in Irish poultry samples since early 2000s (Figure 7). Since 2009, there has been a steady decrease in the rate of anticoccidial positives due to the setting of maximum residue limits for a range of these compounds. Consequently, the likelihood of non-compliant samples has been greatly reduced, particularly for nicarbazin due to the change of the MRL from 200 µg/kg to 15,000 µg/kg. Some positives are still encountered for ionophores and toltrazuril. Surprisingly few positives have been reported for other drug residues in poultry. No non-compliant results have been found for antibacterial drug residues since 2004.

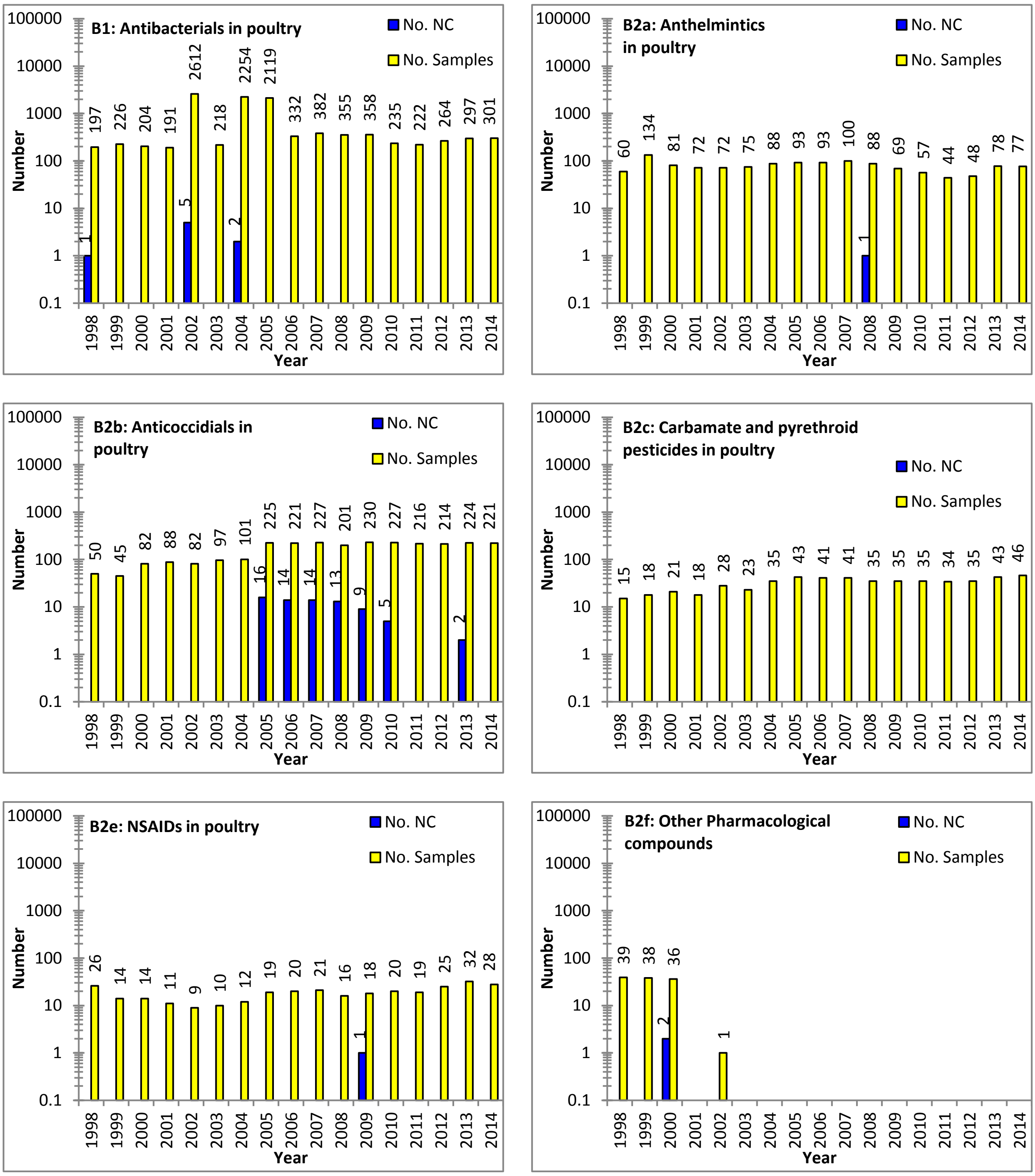


Figure 7: Results for the monitoring of Group B1 and B2 substances in poultry samples collected in the Republic of Ireland between 1998 and 2014. Yellow and blue bars denote number of samples analysed and non-compliant (NC) results, respectively. No samples were analysed for B2d sedatives.

The 2008 EU testing programme identified non-compliant residues in 179 poultry meat samples; this number had reduced to 13 by 2012 (0.16% of samples). Since 2011, the ionophores (lasalocid, maduramycin, monensin, salinomycin and semduramicin) are the most frequently detected anticoccidial residues. Since 2011, antibacterials were responsible for the greatest number of positives in poultry with 24 non-compliant results (Figure 8). These correspond to results from 18,412 test samples (overall positive rate of 0.12%).

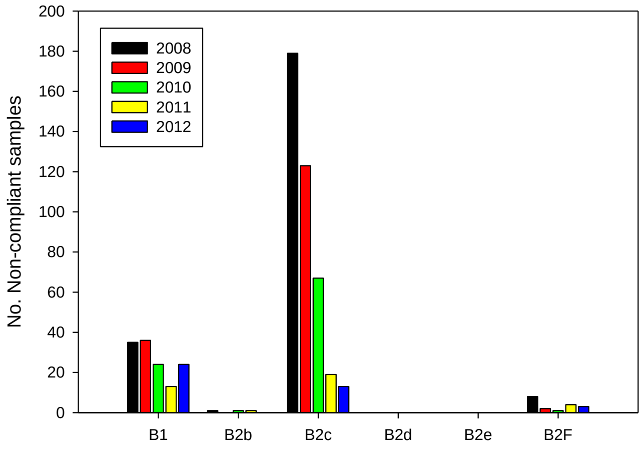


Figure 8: Non-compliant results for Group B1 and B2 substances in EU poultry between 2008 and 2012.

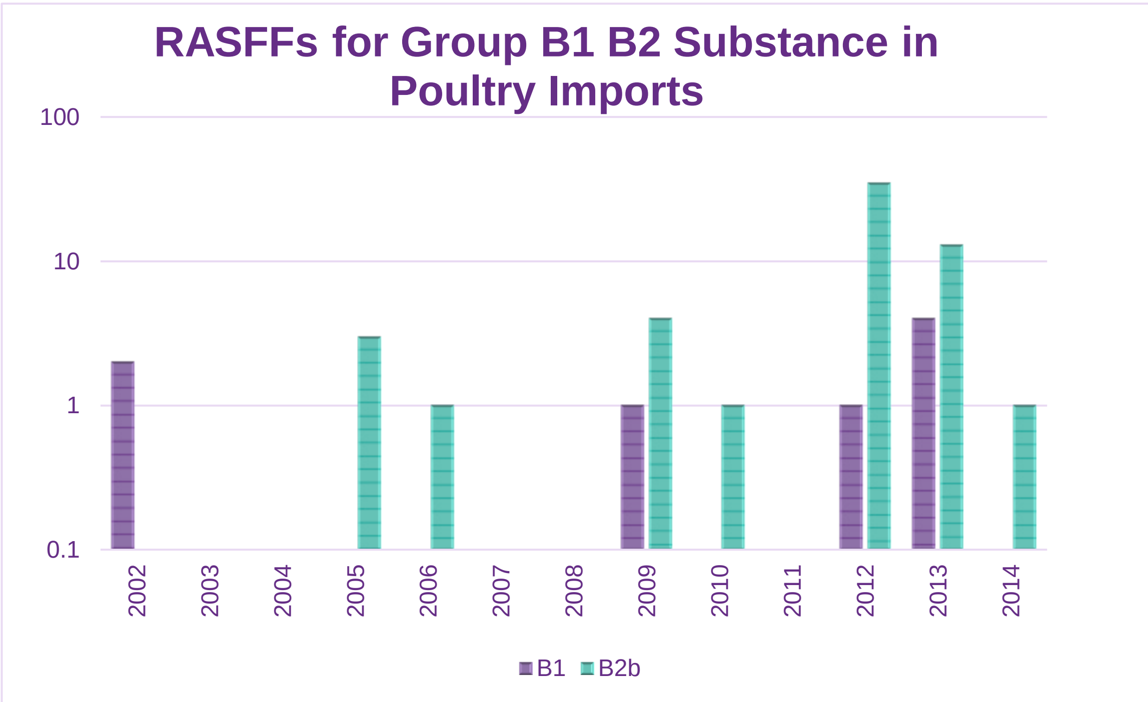


Figure 9: Non-compliant results for Group B substances in poultry imported into the EU between 2002 and 2014.

EU monitoring results for group B substance in imported poultry are presented in Figure 9. This bar chart results show that there was a low number of non-compliant results in up to 2011 and a large increase in the number of positives in 2012 for anticoccidials. The reason for the increase was due to the detection of clopidol, toltrazuril and cyromazine residues following the implementation of new mass spectrometry based detection methods. The rate of positives decreased in 2013 and only one non-compliant result was observed in 2014.

Analysis of residue occurrence data for pork

Group A substances in Pork

An overview of non-compliant results for group A substances in pork samples collected in the Republic of Ireland between 1998 and 2014 are presented in Figure 10. The rate of non-compliance for group A substances in pork is very low. In Ireland, a total of three and nine poultry samples for thyrostats were found during 2008 and 2009, respectively. The reason for the increased number of positives for thiouracil is due to the implementation of more sensitive analytical tests. It has been reported that residues of thiouracil are most probably caused from feeding cruciferous plants. Pinel et al. (2006) demonstrated that animals fed with cruciferous plants can give erroneous indications of the possible illegal use of thyrostats in meat production animals [29].

EU monitoring results presented in Figure 11 show a slightly different picture, with steroids being the most frequently non-compliant residue followed by banned veterinary drugs (group A6), thyrostats and resorcyclic acid lactones (RALs). One positive result was also found for the beta-agonist, clenbuterol, in 2010. The most frequently reported hormone residue over the years is nandrolone followed by 17- β -nortestosterone, boldenone and more recently androstene-5-3-beta. The non-compliant RAL residues are due to the detection of α -zearalanol (zeranol) and β -zearalanol (taleranol). Both of these substances are metabolites of the mycotoxin zearalenone, which is produced by Fusarium species frequently detected in feed. In all cases it was reported that there was no evidence of use of illegal growth promoting agents and that feed contamination was suspected. This was verified in some cases by co-detection of mycotoxin residues (zearalenone and its metabolites). Chloramphenicol is the most widely detected of the group A6 banned drugs followed by semicarbazide (marker residue for nitrofurazone) and metronidazole residues.

Monitoring for group A substances in imported pork, show that the majority of residues are due to chloramphenicol and nitrofuran residues in casings (Figure 12). There were no non-compliant results in 2013 or 2014, while only one positive has been found in 2015.

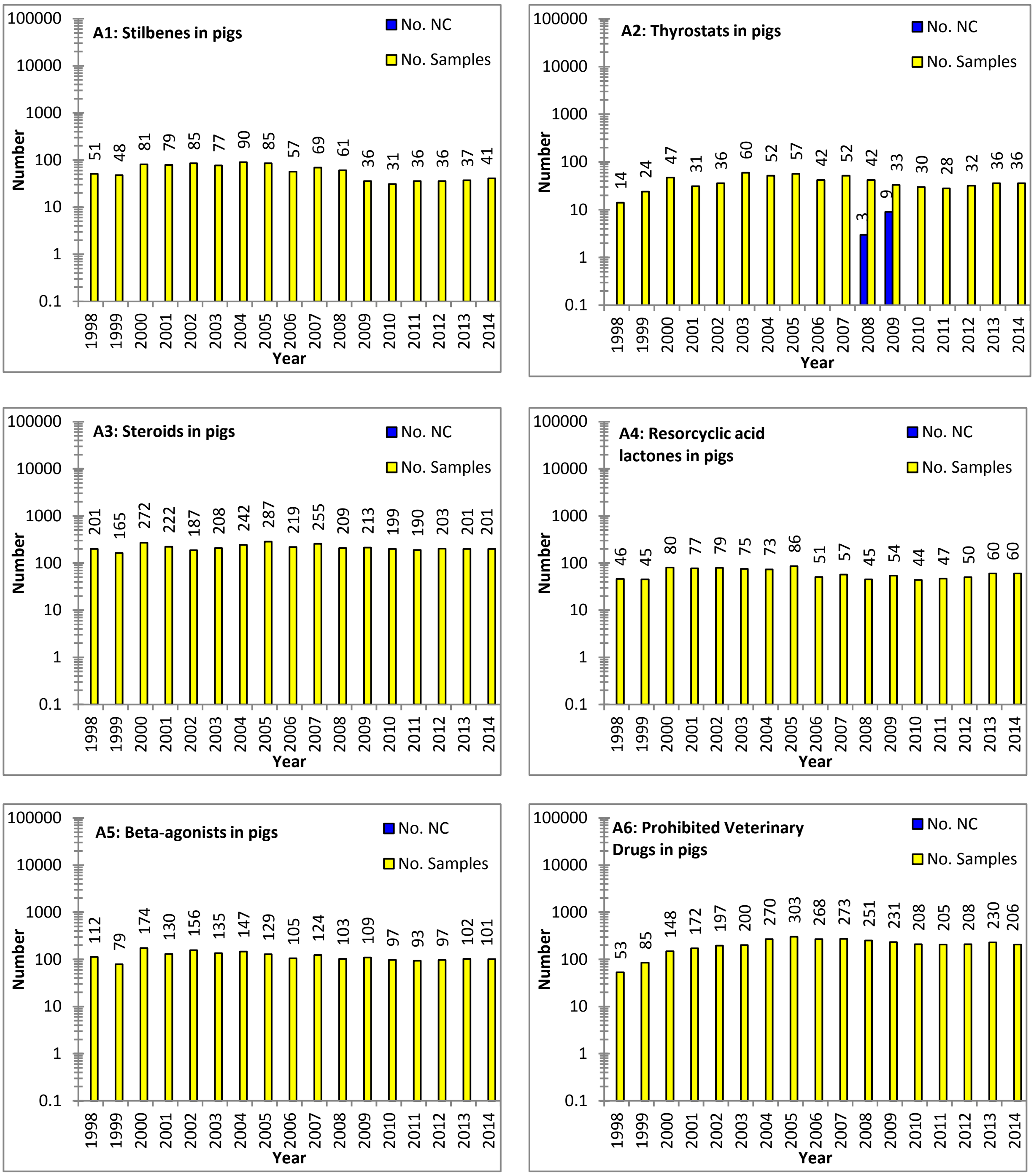


Figure 10: Results for the monitoring of Group A substances in pig samples collected in the Republic of Ireland between 1998 and 2014. Yellow and blue bars denote number of samples analysed and non-compliant (NC) results, respectively.

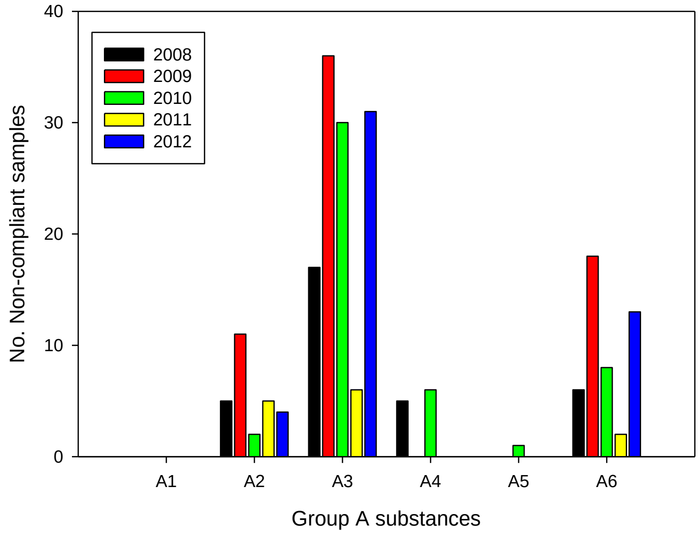


Figure 11: Overview of EU wide positives for Group A substances in pork samples.

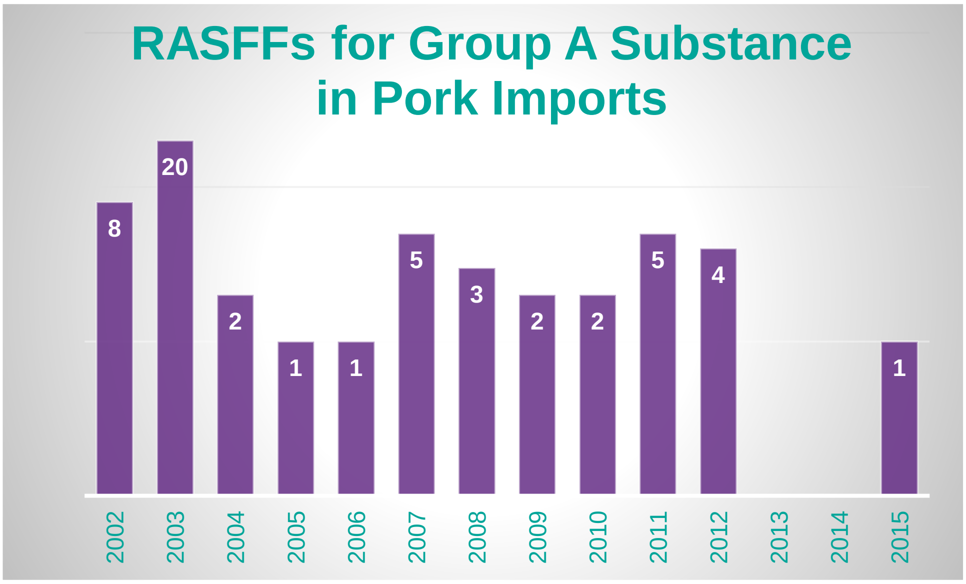


Figure 12: EU non-compliant results for Group A substances in imported pork.

Group B substances in pork

The antibacterials are the most important group B residue in Irish pork (Figure 13). Since 1998, the only other group B1 or B2 substances that were detected in pork were the anticoccidials and the carbadox (Figure 14). The antibacterials also give rise to the most reports of non-compliant residues in EU work but they appear to be decreasing from 2008 to 2012 (Figure 15). The incidence of group B2 positives in pork is generally very low between 2008 and 2012.

Results are also presented for group B3 contaminants in Irish pork (Figure 14). In general, the incidence of these substances in pork are low. However, a number of non-compliant results were reported in pork during the Irish dioxins crisis in the period 2008 to 2009. This crisis costed the Irish taxpayer in the region of €200 million [30]. This crisis highlights the need for ongoing surveillance of these substances in feed and pork.

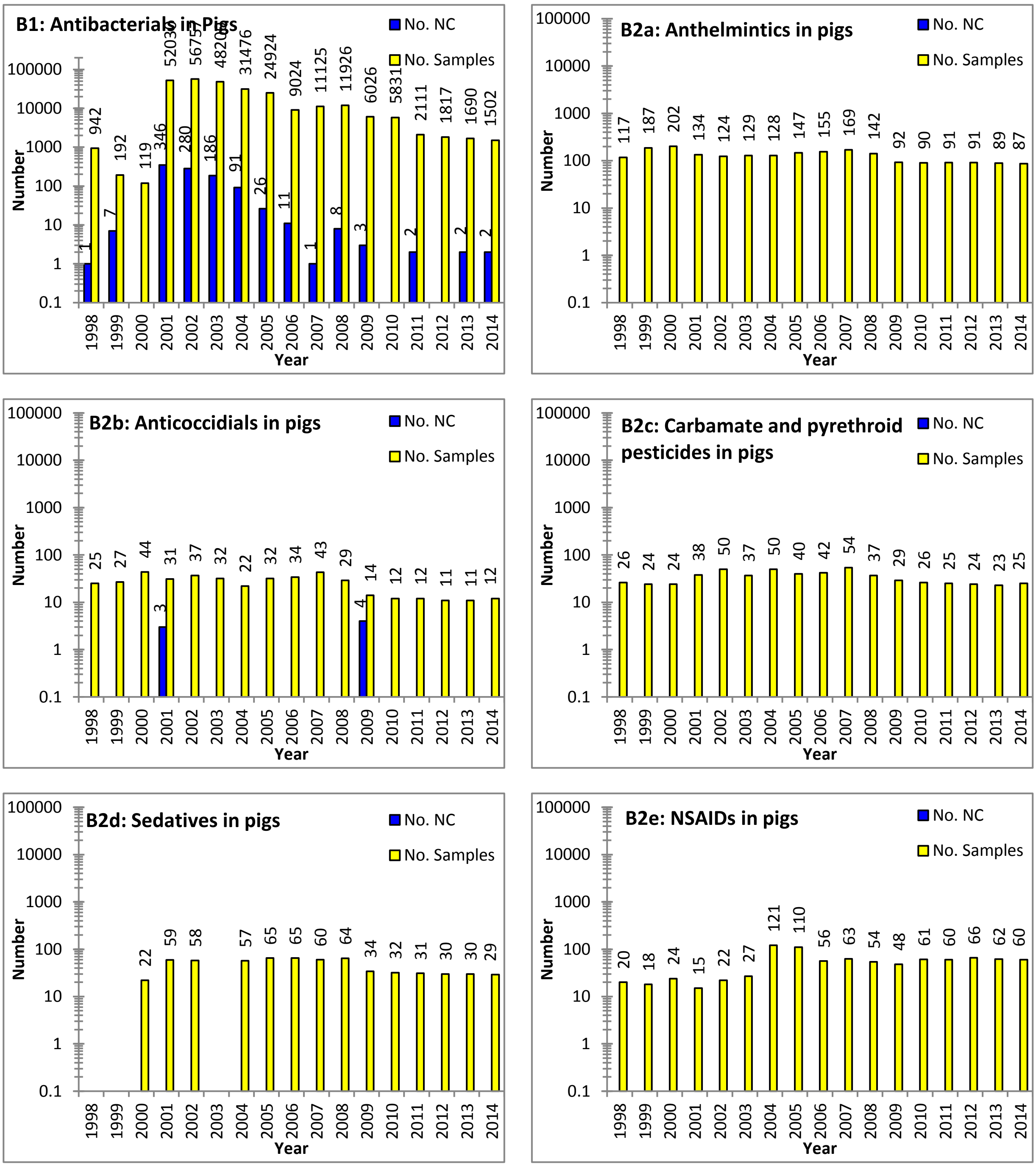


Figure 13: Results for the monitoring of Group B1 and B2 substances in pig samples collected in the Republic of Ireland between 1998 and 2014. Yellow and blue bars denote number of samples analysed and non-compliant (NC) results, respectively. B2f substances are shown in Figure 14.

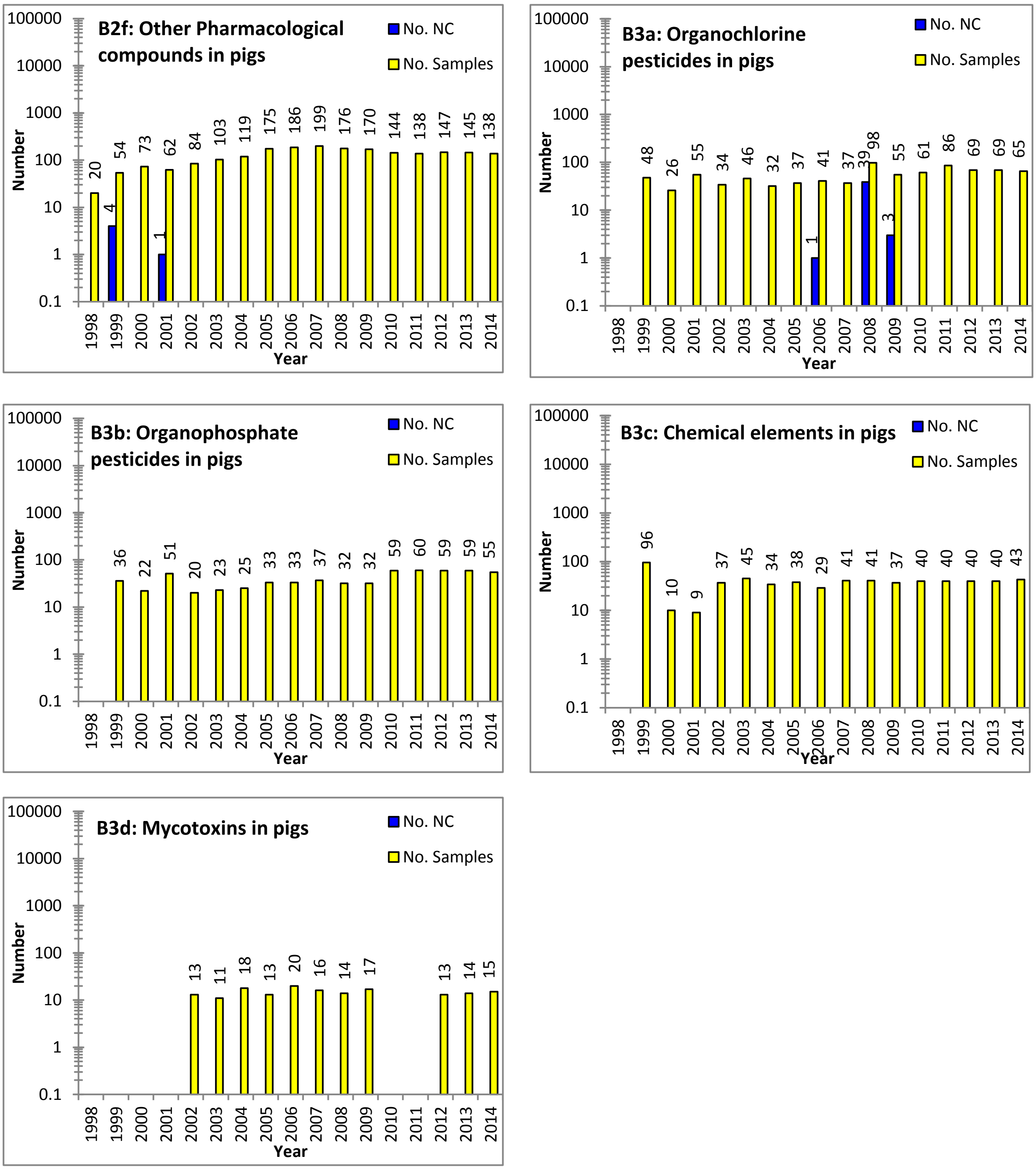


Figure 14: Results for the monitoring of Group B2f substances and B3 contaminants residues in pig samples collected in the Republic of Ireland between 1998 and 2014. Yellow and blue bars denote number of samples analysed and non-compliant (NC) results, respectively.

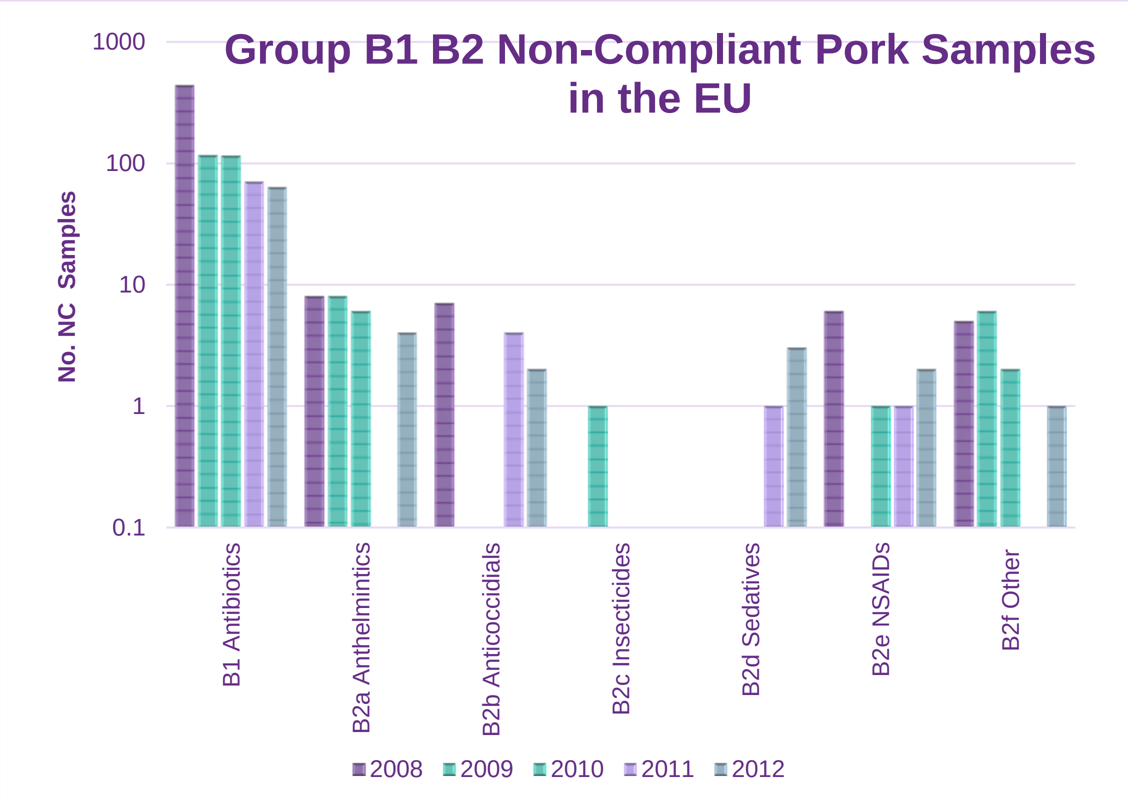


Figure 15: Non-compliant results for Group A and Group B substances in EU pork between 2008 and 2012.

Recommendations for the Poultry and Pork sectors

The choice of residues to monitor in poultry and pork meat largely depends on a number of factors including source of the product and specifications for clients.

In the case of poultry meat, the incidence of group A substances in meat is generally very low. However, it is recommended that a risk analysis should be carried out through a review of residue control plans results for the source country. The most important group A substances for poultry meat are group A6. In particular, chloramphenicol residues and to a lesser extent nitroimidazoles and nitrofurans. It is recommended when sourcing product from outside of the EU that batches of poultry should be analysed for the above residues. It is also important to note, that interest in chloramphenicol has increased in recent years due to the presence of low residue levels in meat samples. Therefore, it is recommended that some analysis be carried out of this substance in domestic poultry meat also.

In relation to group B substances, the antibiotics and the anticoccidials are the most important residues to monitor in poultry. In general, low cost (<€10 per sample) inhibitory screening approaches can be used for antibiotic analysis in meat and it makes sense to use these methods to satisfy compliance. In relation, to anticoccidials there has been a shift in priority in target analytes in recent years due to changes in EU tolerances. Presently, the most important residues to monitor in European poultry are the ionophores (monensin, salinomycin, narasin, lasalocid, maduramycin and semduramicin) and toltrazuril sulphone. In relation to poultry imported from outside of the EU, analysis should be extended to a wider range of residues including clopidol and cyromazine. There are a number of anticoccidial agents that are not currently licensed in the EU that can potentially be used in Third countries. At present, no suitable methods are available for some of these compounds and consequently they are not monitored routinely in meat [31]. In the event that methods are implemented in residue testing laboratories for these compounds there is a potential for reports of new emerging anticoccidial residues in imported meat.

In relation to pork, the steroids are an important group of residues and in particular nandrolone residues. In addition, chloramphenicol residues should be monitored in pork because of increasing reports of positives in recent years. Recent research has indicated that some of these positive findings may be due to contaminated crops [32]. In relation to group B substances the most important residues are antibacterials. Other pharmacological substances of importance include the tranquilisers/sedatives, quinoxalines and PCBs.

Compositing samples to reduce cost

Background

Chemical contaminant residues can be monitored in pork and poultry products using a range of techniques. These can include low cost screening procedures such as bacterial inhibition tests (costing <€10 per sample) to more expensive chemical tests, which cost hundreds of euros per sample. Chemical analysis tests require laborious sample preparation steps, costly reagents/chemicals, and expensive analytical instrumentation such as liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS). In this report, compositing of samples is presented as an approach to reducing chemical analysis costs for the Pork and Poultry industry, along with advantages and disadvantages. In advance of deciding to composite samples, it is important to consider that following questions should be considered:

What is the likelihood of residues being detected in samples?

If there is a relatively low probability of residues being detected in samples then samples should be composited. Typically, with veterinary drugs the likelihood of finding a non-compliant residue in a sample is very low i.e. less than 1%. Therefore, if 10 composite samples were prepared from 100 individual samples, residues would probably be detected in one out of 10 composite samples at most. In such a case, all 10 samples that made up this composite sample should be retested. Consequently, out of the 100 original samples only 20 tests would have to be performed at the maximum. See Appendix 1 for the method to prepare a composite sample.

How does the sensitivity of analytical methods impact on compositing?

Anthelmintic in pork example:

Doramectin, fenbendazole, flubendazole and ivermectin are anthelmintic drugs that can be used in pig production. The Maximum Residue Limits for these substances in pig liver tissue are 100, 500, 400 and 100 µg/kg, respectively. Available analytical methods for these substances can routinely measure residues to less than 5 µg/kg. Potentially, 20 samples could be mixed together to dilute a potential MRL breach sample (sample exceeding >100 µg/kg) to greater than 5 µg/kg. However, it is recommended to composite a maximum of 10 samples, thus targeting a level of 10 µg/kg.

Nitrofurans in poultry or pork example:

Nitrofuran residues can be measured in poultry or pork muscle tissue samples to less than 0.1 µg/kg using LC-MS/MS. The Reference Point for Action for nitrofuran residues in muscle tissue is 1 µg/kg. Therefore, a composite sample should be formed from 5 individual samples.

Anticoccidials in poultry example:

In the case of anticoccidials, these substances can be typically detected in muscle tissue to 1 μg/kg. The compositing of poultry meat samples is limited by the MRLs for monensin and salinomycin of 8 and 5 μg/kg, respectively (Table 3). Therefore, to allow more effective compositing of meat samples a more sensitive method is required that will allow the measurement of monensin and salinomycin to 0.40 and 0.25 μg/kg, respectively.

Table 3: MRLs for selected anticoccidials in poultry tissues

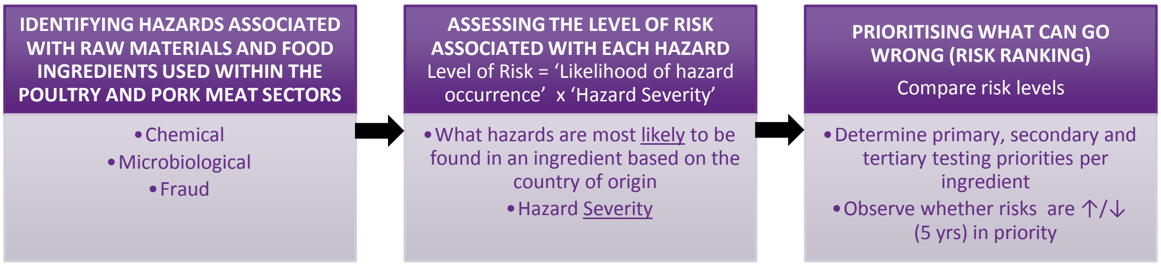
Anticoccidials	Species	Muscle (μg kg^{-1})	Liver (μg kg^{-1})
Nicarbazin	Chicken	4000	15000
Monensin	Poultry	8	8
Lasalocid	Poultry	20	100
Salinomycin	Broiler	5	5
Narasin	Broiler	50	50
Maduramycin	Poultry	30	150
Robenidine	Broiler	200	800
Robenidine	Turkey	200	400
Decoquinate	Broiler	500	1000
Diclazuril	Poultry	500	1500
Toltrazuril	Poultry	100	600

5 Objective 3

Food Hazard Alert Database

Risk Management Process

Below is a schematic of the process used for risk management.



The following sections provide a breakdown of the data extracted and how the Food Risk Register/Database was constructed for the white meat sector.

Hazard Identification

A database was constructed by QUB detailing the reported food notifications generated during the period 2009 to 2013 from the EU Rapid Alerts System for Food & Feed (RASFF) [33]. The raw materials/food ingredients highlighted included alcoholic beverages, cereals, eggs, fats and oils, food additives and flavourings, fruits and vegetables, herbs, spices, honey, meats and meat products (other than poultry), milk and milk products, non-alcoholic beverages, peanuts and tree nuts, oilseeds and other seeds (excluding oil), other food products, poultry meat and poultry meat products, soups, broths, sauces and condiments and water. A total of 7635 notifications were identified and assigned to one of fourteen subheadings: Industrial Contaminants, Heavy Metals, Prohibited Veterinary Products, Total (Mycotoxins & Biotoxins), Unauthorised Pesticides, Unauthorised Veterinary Products, Pathogenic micro-organisms, Approved Pesticides, Parasitic Infestation, Allergens, Legal Veterinary Products, Food Additives and Flavourings, Composition and Non Pathogenic micro-organisms. Country of origin data was produced relating to the commodities used on the ioI in addition to the frequency of hazard notifications over the five year period from 2009 to 2013 for all food commodities.

Hazard Severity

Risk management involves looking at the probability of a hazard occurring and then taking into consideration the magnitude of its impact. To rank the risks and therefore determine the testing priorities of the various ingredients used by the white meat sector on the ioI, the frequency of each identified hazard, in a particular food group was multiplied by a hazard severity score. The hazard severity scoring system has been devised for the following categories Industrial Contaminants, Heavy Metals, Prohibited Veterinary Products, Total (Mycotoxins & Biotoxins), Unauthorised Pesticides, Pathogenic Micro-organisms, Approved Pesticides, Unauthorised Veterinary Products, Parasitic Infestation, Allergens, Food Additives and Flavourings, Legal Veterinary Products, Composition and Non-pathogenic Micro-organisms. The scores are derived from the scientific information relating to acute effects, carcinogenicity, genotoxicity and long-term effects and the sum of the scores for each give the hazard severity score (Table 4) used to assess testing priorities.

Table 4: Hazard Severity Score

Hazard Category	Score
Industrial Contaminants	38
Heavy Metals	33
Prohibited Veterinary Products	31
TOTAL (mycotoxins+biotoxins)	28
Unauthorised pesticides	19
Unauthorised Veterinary Products	16
Pathogenic micro-organisms	15
Approved Pesticides	14
Parasitic Infestation	13
Allergens	12
Legal Veterinary Products	8
Food Additives and Flavourings	7
Composition	5
Non Pathogenic micro-organisms	5

Risk Ranking & Testing Priorities

The information within the constructed risk register/database allows for the accurate identification of the frequency of hazards (2009 to 2013 data) and the severity associated with each hazard (section

5.1.2). Based on these parameters, by multiplying the frequency of notification for each hazard (total) by the risk score, the value generated can then be used to prioritise analyses for each commodity.

Non-ranked notifications

There were five further hazard categories which did not fall within the developed scoring system as this was based on acute effects, carcinogenicity, genotoxicity and long-term effects which did not apply to certain hazard categories. However it is important that companies are aware of these hazards and be proactive in minimising the risk associated with the various food groups affected. The hazards included Adulteration/Fraud, Chemical contamination (other), foreign bodies, GMO & Novel Food and Labelling absent/incomplete/incorrect.

Trend analysis for the periods 2009-2013 and 2010-2014

The number of notifications for hazard categories were compared over the five year periods as outlined above to ascertain any trends in the data.

Industry questionnaires

Tables 5-8 outline the responses to the questionnaires sent to each study participant. Although stakeholder engagement in the pilot study was low, major pork and poultry companies on the ioI were involved, covering a huge array of products and production rates. All companies enforced stringent Quality Assurance/Control measures that were updated according to changes in legislation and the focus of these systems was primarily for food safety and hygiene, although many of the companies were aware of food fraud. In terms of risk assessment, most agreed that there was sufficient information for them to adequately determine the risks associated with meat and poultry, however not in terms of other raw materials used in the preparation of their products. All participants provided a list of their ingredients used which ranged from 20 to > 700 depending on the size of the company that were sourced from various trusted suppliers (10-150) according to quality, cost and location. None of the participating companies associated specific hazards/risks with particular geographical regions, although all meat was sourced from ioI, the United Kingdom or Europe while other ingredients were global. The testing applied to their raw materials/finished products included veterinary drug residues, pathogens, pesticides and mycotoxins, specifically aflatoxin B1. In terms of hazards associated with the commodities, *Salmonella*, *Campylobacter*, *E. coli*, *Bacillus cereus* and *Listeria* were mentioned. Antibiotics were the main veterinary drug residues highlighted and the chemical hazards listed included refrigerants, cleaning materials, dioxins, maintenance oils and pesticides. Allergens identified included milk, gluten, eggs, celery, mustard, soya and nuts.

Table 5: Company demographics

Question	Response
Type of establishment	1 x Pig Slaughterhouse/cutting plant/meat products and preparation site. 3 x Poultry slaughterhouse/cutting plant/meat products and preparation site. 2 x Pork/poultry meat products. 1 x Poultry meat products.
Types of products	Fresh meat. Chilled, frozen, marinated, breaded, battered, flavoured and stuffed chicken products, ready to eat/cook categories. Savoury pastry products (pork and poultry).
Number of products	10 – 1500.
Production rate	135 – >300 tonnes finished product/week.

Table 6: Company control systems

Question	Response
QA/QC systems in place	Quality Management System, BRC standards, HACCP, Bord Bia, Red Tractor, Quality British Turkey. In-house testing of raw materials/finished product. Certificates from suppliers. FC24 (the Food and Environment Research Agency). RASFF (Rapid Alert System for Food and Feed). Poultry is fully traceable from pack right back to the breeder flock from which the chicks came.
In-house/Industry Standard	Both.
Focus of the control system	Primarily food safety and hygiene but aware of fraud.
Is the control system regularly updated	Updated according to risks and/or legislation.
Sources of information regarding risks	On-site vet, legislation, RASFFs, FSA alerts, Environmental Health, Teagasc, Industry Sources and Campden.
Is there sufficient information to adequately assess risk	Sufficient in terms of meat but not for other high risk ingredients/raw materials.

Table 7: Choice and suppliers of raw materials and ingredients

Question	Response
List of raw materials/ingredients supplied	Yes.
Number of raw materials/ingredients	20 - >700.
Number of suppliers	10 - 150.
Basis of supplier choice	Cost, quality, location.
How often are suppliers changed	Rarely.
Are raw materials/ ingredients selected based on geographic origin	Pigs, poultry from IoI, UK or Europe. Dry ingredients are global.
Do you associate specific hazards/risks with particular geographic areas	No.

Table 8: Monitoring and perception of risks

Question	Response
What testing regimes do you have in place	Veterinary drug residues, pathogens, pesticides and aflatoxin B1.
What microbiological hazards pose the greatest risk for your products	*Salmonella, E. coli, Listeria, B. cereus, Campylobacter*.
What chemical hazards pose the greatest risk for your products	Refrigerants, cleaning chemicals, maintenance oils, antibiotics, pesticides and dioxins.
What allergens pose the greatest risk for your products	Milk, gluten, eggs, celery, mustard, soya and nuts.
What veterinary hazards pose the greatest risk for your products	Antibiotics.

RASFF Hazard Identification

From the RASFF notifications, country of origin data has been produced relating to the commodities used on the IoI and Figure 15 highlights the results for countries with 100 or more notifications related to food. In summary, Turkey had the highest number of notifications (1155), followed by China (875) and India (730). A further 103 countries had less than 100 notifications (data not shown).

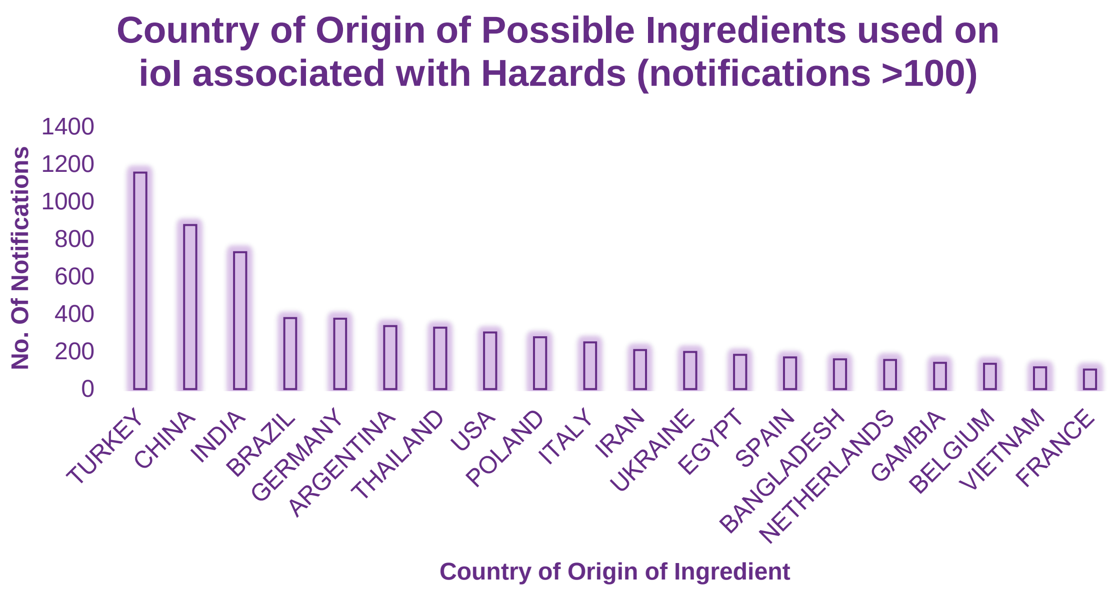


Figure 15: Country of Origin of commodities

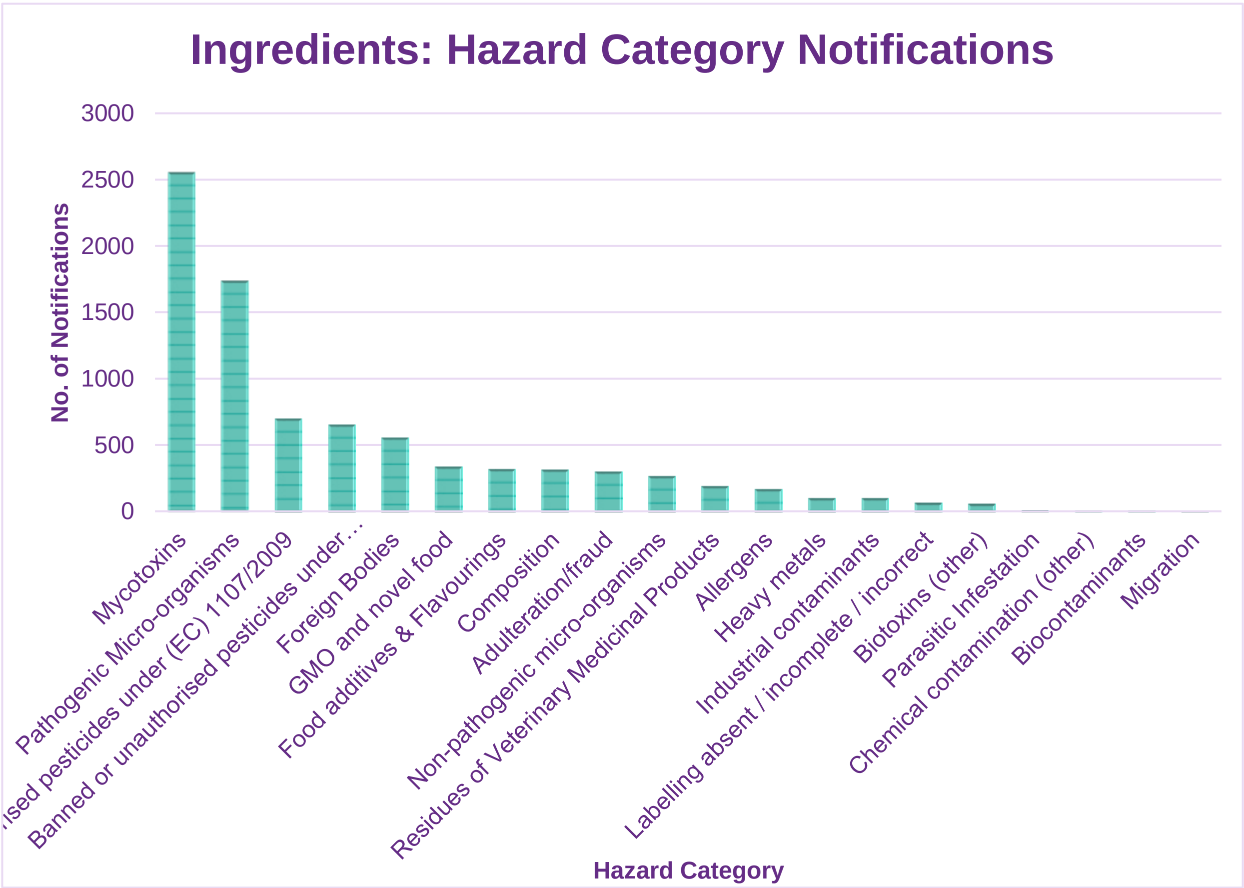


Figure 16: Frequency of Hazard Category Notifications

Figure 16 shows the frequency of hazard notifications over the five year period from 2009 to 2013 for food. The data demonstrates that approximately 75% of hazard notifications are due to contamination with mycotoxins (33%), pathogenic micro-organisms (23%), authorised pesticides (9%) and unauthorised pesticides (9%) with the remaining 25% due to the other hazard categories detailed.

By combining the data in Figures 15 and 16, the chart outlined in Figure 17 illustrates the number of notifications reported during the period 2009 to 2013, the hazard categories identified and the country of origin. This not only provides valuable information to the industry on the risks associated with particular ingredients but also in determining where to source their raw materials.

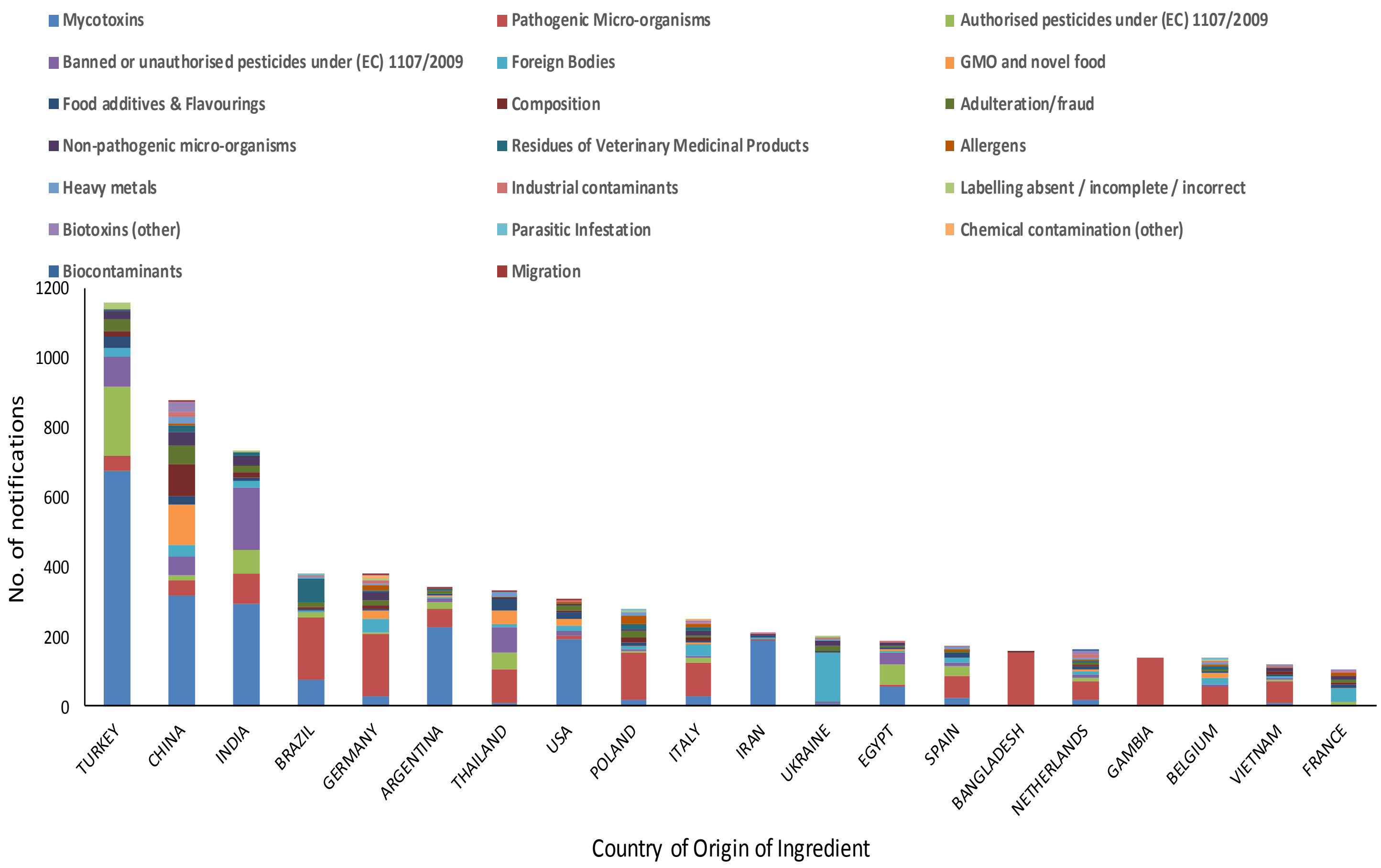


Figure 17: Combined data related to the country of origin, the number of notifications and the associated hazard.

Hazard Severity

As described previously to rank the risks and therefore determine the testing priorities of the various ingredients used by the white meat sector on the ioI, the frequency of each identified hazard, in a particular food group was multiplied by a hazard severity score. Table 4 outlines the scores associated with specific hazards and Tables 9 and 10 indicate the frequency of RASFF notifications for each hazard and each food category over the 2009 to 2013 period. When these two components are multiplied together an overall score helps to rank the hazards associated with specific commodities (Table 10). For example, for meat and meat products other than poultry, the total number of notifications for pathogenic micro-organisms over the 2009 to 2013 period was 438. The hazard severity score calculated for pathogenic micro-organisms based on acute and long term effects, carcinogenicity and genotoxicity was 15. Therefore the hazard score is 438 x 15, i.e. 6570. Scores were calculated for each food commodity allowing the risks to be prioritised.

Risk Ranking & Testing Priorities

The scores generated as shown were then used to prioritise analyses for each commodity. Table 11 subsequently highlights the major hazards associated with individual commodities (i.e. the testing that should be undertaken; primary, secondary and tertiary risks) and Tables 12 & 13 outline the remaining hazard risks associated with these particular commodities. For 39% of commodities the primary risk is pathogenic micro-organisms, for 28% mycotoxins and biotoxins, for 11% the primary risk is food additives and flavourings while industrial contaminants, residues of prohibited veterinary medicinal products, residues of unauthorised veterinary medicinal products and banned or unauthorised pesticides under (EC) 1107/2009 are the primary risks each affecting 5.5% of the commodities of interest. Figure 18 also represents the testing priorities for each food ingredient in a chart format.

Table 9: Frequency of notifications for each hazard per year from the RASFFs

	Allergens					Biotoxins (other)					Composition					Food additives & flavourings					Heavy metals					Industrial contaminants					Migration				
	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009
Alcoholic beverages	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	5	4	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cereals	12	21	19	6	6	1	1	0	0	0	11	24	41	9	4	3	6	5	9	6	0	4	0	1	2	1	0	2	0	1	0	0	0	0	0
Eggs	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	1	2	0	0	0	0	0	0
Fats and oils	0	0	1	0	0	0	0	0	0	0	5	3	3	8	9	0	0	0	0	0	0	1	0	0	0	4	6	9	7	6	0	0	0	0	0
Food additives and flavourings	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	0	1	1	0	0	0	0	1	0	3	0	0	0	0	0
Fruits and vegetables	0	1	4	1	1	3	0	1	3	0	14	11	16	14	16	17	21	22	28	29	8	15	12	13	18	4	0	5	2	1	0	0	1	1	0
Herbs	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Spices	1	2	0	1	2	0	0	0	0	1	2	4	13	14	19	4	3	2	4	8	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0
Honey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Meats and meat products (other than poultry)	5	3	10	4	9	0	0	0	1	0	3	2	1	1	2	3	6	3	6	8	0	1	6	0	2	0	5	3	1	1	0	0	0	0	1
Milk and milk products	1	2	0	0	1	0	0	0	0	2	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0
Non-alcoholic beverages	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	5	7	2	6	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Peanuts and tree nuts	3	0	1	3	0	1	4	36	0	0	1	0	0	2	0	1	2	2	3	6	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Oilseeds and other seeds (excluding oil)	0	0	2	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0
Other Food products	1	0	0	2	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poultry meat and poultry meat products	6	2	2	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	2	0	0	0	0	0	0	1
Soups, broths, sauces and condiments	9	4	6	10	5	0	0	0	2	0	0	11	15	8	9	8	13	15	13	13	0	0	1	1	1	0	1	2	5	6	1	0	0	0	0
Water	0	0	0	0	0	0	0	0	0	0	0	1	0	5	2	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1
Total Alerts	38	36	45	29	25	5	5	38	7	3	37	64	89	63	62	42	68	55	75	78	11	27	23	15	23	11	18	33	17	22	1	0	1	1	3
Totals	173					58					315					318					99					101					6				

Table 9 continued: Frequency of notifications for each hazard per year from the RASFFs

	Mycotoxins					Non-pathogenic micro-organisms					Parasitic infestation					Pathogenic-micro-organisms					Banned or unauthorised pesticides under (EC) 1107/2009					Authorised pesticides under (EC) 1107/2009					Residues of Veterinary Medicinal products				
	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009
Alcoholic beverages	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cereals	28	28	30	27	19	2	3	7	4	3	0	1	0	0	0	0	2	1	1	1	1	1	5	0	2	3	5	1	0	0	0	0	0	0	0
Eggs	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	6	7	6	9	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Fats and oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food additives and flavourings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	1	1	1	1	0	0	0	0	0	0	0	0	19	0	0	0	0
Fruits and vegetables	70	151	89	69	61	6	20	18	21	11	0	0	0	0	0	40	23	37	14	25	199	200	148	96	94	205	170	190	175	65	0	0	0	0	0
Herbs	0	0	0	0	0	1	1	2	2	0	0	0	0	0	0	68	87	133	22	32	27	43	16	19	16	25	38	14	15	12	0	0	0	0	0
Spices	42	40	68	127	34	4	2	5	4	5	0	0	0	0	0	17	20	21	13	5	1	1	1	1	0	0	1	0	2	1	0	0	0	0	0
Honey	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	6	6	7	10
Meats and meat products (other than poultry)	0	0	0	0	0	0	1	2	3	3	0	2	0	2	5	128	94	70	84	62	0	0	0	0	0	0	0	1	0	0	24	18	41	26	6
Milk and milk products	1	5	0	0	0	4	6	6	22	3	0	0	0	0	0	27	28	27	28	17	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3
Non-alcoholic beverages	3	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peanuts and tree nuts	200	175	284	395	459	5	18	3	5	8	0	0	0	0	1	5	10	3	13	6	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Oilseeds and other seeds (excluding oil)	4	19	15	14	21	1	1	21	9	2	0	0	0	0	0	7	10	8	11	19	1	1	1	3	2	1	0	1	1	0	0	0	0	0	0
Other Food products	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	2	3	0	1	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poultry meat and poultry meat products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	184	62	50	58	71	0	0	0	0	0	0	2	0	0	0	10	6	0	0	3
Soups, broths, sauces and condiments	8	12	9	12	26	1	0	3	2	0	0	0	0	0	0	5	9	3	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	0	0	0	0	0	1	1	5	1	1	0	0	0	0	0	0	3	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Alerts	356	431	495	645	625	25	55	73	74	37	0	3	0	2	6	488	359	362	267	263	231	247	171	121	115	234	216	207	193	78	57	30	48	34	22
Totals			2547					264					11					1739					885					928					191		

Table 10: Hazard Severity (Risk Score x Frequency of Risk i.e. 15 x 438)

	Allergens	Composition	Food additives & Flavourings	Heavy metals	Industrial contaminants	Mycotoxins/ Biotoxins	Non-pathogenic micro-organisms	Parasitic Infestation	Pathogenic Micro-organisms	Banned or unauthorised pesticides under (EC) 1107/2009	Authorised pesticides under (EC) 1107/2009	Residues of authorised veterinary medicinal products	Residues of unauthorised veterinary medicinal products	Residues of prohibited veterinary medicinal products
Alcoholic beverages	0	5	126	0	0	28	5	0	0	0	0	0	0	0
Cereals	768	445	203	231	152	3752	95	13	75	171	126	0	0	0
Eggs	0	5	0	0	418	0	5	0	465	19	0	8	0	0
Fats and oils	12	140	0	33	1216	0	0	0	30	0	0	0	0	0
Food additives and flavourings	0	10	14	66	152	0	0	0	90	38	0	0	0	589
Fruit and vegetables	84	355	819	2178	456	12516	380	0	2085	14003	11270	0	0	0
Herbs	12	5	7	33	38	0	30	0	5130	2299	1456	0	0	0
Spices	72	260	147	66	38	8736	100	0	1140	76	56	0	0	0
Honey	0	0	0	0	0	140	0	0	0	19	0	0	384	279
Meats and meat products (other than poultry)	372	45	182	297	380	28	45	117	6570	0	14	192	1024	837
Milk and milk products	48	5	14	0	114	224	205	0	1905	0	0	32	0	0
Non-alcoholic beverages	0	10	168	33	0	112	5	0	15	0	0	0	0	0
Peanuts and tree nuts	84	15	98	0	114	43512	195	13	555	38	0	0	0	0
Oilseeds and other seeds (excluding oil)	36	10	14	33	114	2044	170	0	825	152	42	0	0	0
Other Food products	36	10	0	0	0	28	10	0	270	0	0	0	0	0
Poultry meat and poultry meat products	144	0	0	132	76	28	0	0	6375	0	28	120	32	62
Soups, broths, sauces and condiments	408	215	434	99	532	1932	30	0	405	0	0	0	0	0
Water	0	40	0	66	38	0	45	0	150	0	0	0	0	0

Table 11: Priority testing ranking per commodity

Product ingredient category	Primary Risk	Secondary Risk	Tertiary Risk	Other Risks	Other Risks
Alcoholic beverages	Food Additives & Flavouring	Mycotoxins/ Biotoxins	Composition Non-pathogenic organisms		
Cereals and bakery products	Mycotoxins/ Biotoxins	Allergens	Composition	Heavy metals	Food Additives & Flavourings
Egg and egg products	Pathogenic micro-organisms	Industrial contaminants	Banned or unauthorised pesticides under (EC) 1107/2009	Residues of authorised veterinary medicinal products	Composition
Fats and oils	Industrial contaminants	Composition	Heavy metals	Pathogenic micro-organisms	Allergens
Food additives and flavourings	Residues of prohibited veterinary medicinal products	Industrial contaminants	Pathogenic micro-organisms	Heavy metals	Banned or unauthorised pesticides under (EC) 1107/2009
Fruit and vegetables	Banned or unauthorised pesticides under (EC) 1107/2009	Mycotoxins/ Biotoxins	Authorised pesticides under (EC) 1107/2009	Heavy metals	Pathogenic micro-organisms
Herbs	Pathogenic micro-organisms	Banned or unauthorised pesticides under (EC) 1107/2009	Authorised pesticides under (EC) 1107/2009	Industrial contaminants	Heavy metals
Spices	Mycotoxins/ Biotoxins	Pathogenic micro-organisms	Composition	Food Additives & Flavourings	Non-pathogenic micro-organisms
Honey	Residues of unauthorised veterinary medicinal products	Residues of prohibited veterinary medicinal products	Mycotoxins/ Biotoxins	Banned or unauthorised pesticides under (EC) 1107/2009	
Meat and meat products (other than poultry)	Pathogenic micro-organisms	Residues of unauthorised veterinary medicinal products	Residues of prohibited veterinary medicinal products	Industrial contaminants	Allergens
Milk and milk products	Pathogenic micro-organisms	Mycotoxins/ Biotoxins	Non-pathogenic micro-organisms	Industrial contaminants	Allergens
Non-alcoholic beverages	Food Additives & Flavourings	Mycotoxins/ Biotoxins	Heavy metals	Pathogenic micro-organisms	Composition
Nuts, nut products and seeds	Mycotoxins/ Biotoxins	Pathogenic micro-organisms	Non-pathogenic micro-organisms	Industrial contaminants	Allergens
Oilseeds and other seeds (excluding oil)	Mycotoxins/ Biotoxins	Pathogenic micro-organisms	Non-pathogenic micro-organisms	Banned or unauthorised pesticides under (EC) 1107/2009	Industrial contaminants
Other food products	Pathogenic micro-organisms	Allergens	Mycotoxins/ Biotoxins	Composition Non-pathogenic organisms	
Poultry meat and poultry meat products	Pathogenic micro-organisms	Allergens	Heavy metals	Residues of authorised veterinary medicinal products	Industrial contaminants
Soups, broths, sauces and condiments	Mycotoxins/ Biotoxins	Industrial contaminants	Food Additives & Flavourings	Pathogenic micro-organisms	Allergens
Water	Pathogenic micro-organisms	Heavy metals	Non-pathogenic micro-organisms	Composition	Industrial contaminants

Table 12: Additional priority testing ranking per commodity

Product ingredient category	Other Risks	Other Risks	Other Risks	Other Risks	Other Risks	Other Risks	Other Risks
Cereals and bakery products	Banned or unauthorised pesticides under (EC) 1107/2009	Industrial contaminants	Authorised pesticides under (EC) 1107/2009	Non-pathogenic micro-organisms	Pathogenic micro-organisms	Parasitic infestation	Parasitic infestation
Egg and egg products	Non-pathogenic micro-organisms						
Food additives and flavourings	Food Additives & Flavouring	Composition					
Fruit and vegetables	Food Additives & Flavouring	Industrial contaminants	Non-pathogenic micro-organisms	Composition	Allergens		
Herbs	Non-pathogenic micro-organisms	Allergens	Food Additives & Flavouring	Composition			
Spices	Banned or unauthorised pesticides under (EC) 1107/2009	Allergens	Heavy metals	Authorised pesticides under (EC) 1107/2009	Industrial contaminants		
Meat and meat products (other than poultry)	Heavy metals	Residues of authorised veterinary medicinal products	Food Additives & Flavourings	Parasitic infestation	Composition Non-pathogenic organisms	Mycotoxins/ Biotoxins	Authorised pesticides under (EC) 1107/2009
Milk and milk products	Residues of authorised veterinary medicinal products	Food Additives & Flavourings	Composition				
Non-alcoholic beverages	Non-pathogenic micro-organisms						
Nuts, nut products and seeds	Banned or unauthorised pesticides under (EC) 1107/2009	Composition	Parasitic infestation				
Oilseeds and other seeds (excluding oil)	Authorised pesticides under (EC) 1107/2009	Allergens	Heavy metals	Food Additives & Flavourings	Composition		
Poultry meat and poultry meat products	Residues of prohibited veterinary medicinal products	Residues of unauthorised veterinary medicinal products	Mycotoxins/Biotoxins Authorised pesticides under (EC) 1107/2009				
Soups, broths, sauces and condiments	Composition	Heavy metals	Non-pathogenic micro-organisms				

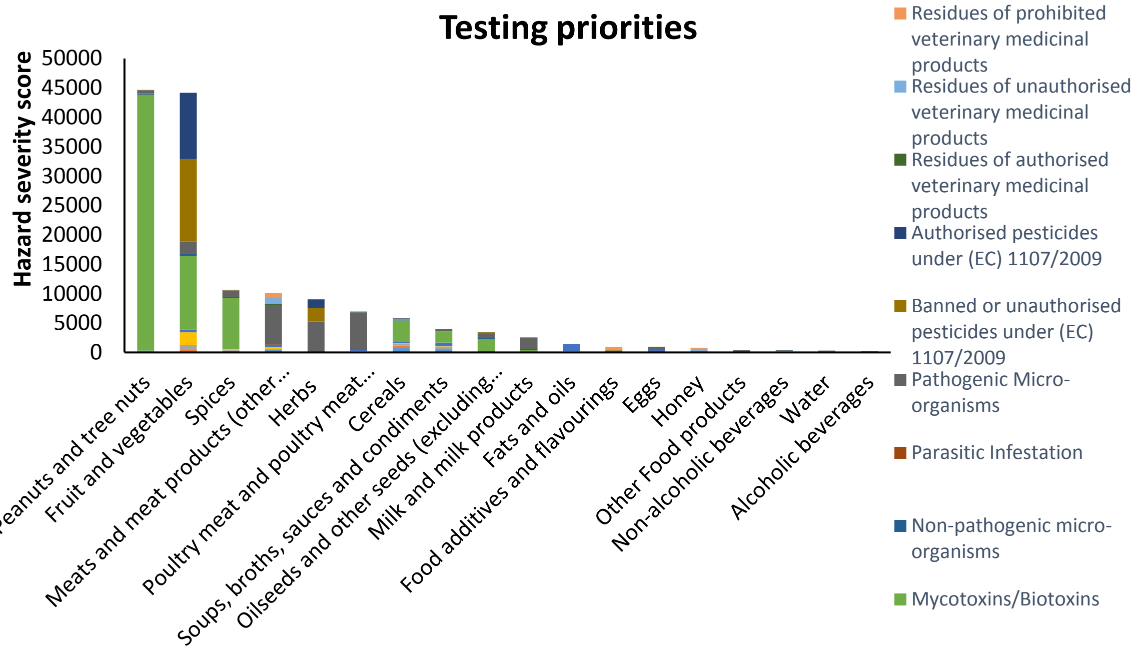


Figure 18: Chart detailing the testing priorities for each food category

Non-ranked Notifications

The five further hazard categories which did not fall within the developed scoring system, i.e. Adulteration/Fraud, Chemical contamination (other), Foreign bodies, GMO & Novel Food and Labelling absent/incomplete/incorrect were tabulated and the numbers of notifications associated with each from January 2009 to December 2013 are shown in Table 13. From the data shown, foreign bodies proved the highest risk, followed by GMO & Novel Food. For Adulteration/Fraud, the number of notifications increased significantly in 2013, corresponding to the horsemeat crisis.

Table 13: Hazards not included in the scoring system

	Adulteration/Fraud					Chemical contamination (other)					Foreign bodies					GMO & Novel Food					Labelling absent/ incomplete/incorrect				
	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009
Alcoholic beverages	0	0	2	0	0	2	1	4	0	0	1	2	4	2	1	0	0	0	0	0	0	1	0	0	0
Cereals	8	4	8	1	2	0	0	0	0	0	11	11	15	13	12	15	41	28	51	30	0	2	1	0	0
Eggs	0	2	2	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	1	1
Fats and oils	1	2	3	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
Food additives and flavourings	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	2	4	4	0	0	0	0	1
Fruits and vegetables	5	1	5	1	3	0	0	0	0	0	23	26	31	38	32	27	11	0	2	3	0	1	3	5	1
Herbs	6	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0
Spices	0	0	2	1	0	0	0	0	0	0	4	4	3	2	5	3	0	1	0	0	0	2	0	1	0
Honey	1	1	3	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0
Meats and meat products (other than poultry)	87	4	1	12	16	0	0	0	0	0	2	7	14	10	3	0	0	0	0	0	5	2	1	4	2
Milk and milk products	0	2	4	3	4	0	0	0	0	0	2	0	4	7	4	0	0	0	0	0	0	0	1	2	0
Non-alcoholic beverages	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	3	1	0	0	0	1	0
Peanuts and tree nuts	16	13	17	4	7	0	0	0	0	0	5	8	19	4	16	0	0	0	0	0	1	1	4	2	0
Oilseeds and other seeds (excluding oil)	1	2	3	1	4	0	0	0	0	0	2	47	86	20	9	0	1	1	21	85	1	0	0	0	0
Other Food products	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Poultry meat and poultry meat products	3	4	3	4	4	0	0	0	0	0	3	2	0	3	1	0	0	0	0	0	1	4	1	0	1
Soups, broths, sauces and condiments	2	2	9	1	1	0	0	0	0	0	5	7	7	8	4	2	0	0	2	1	0	1	1	1	0
Water	0	0	3	0	0	0	0	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Total Alerts	130	37	68	37	49	2	1	5	1	0	59	115	185	110	89	50	55	32	84	124	8	18	14	19	6
Totals	321					9					558					345					65				

Trend Analysis for the periods 2009-2013 and 2010-2014

Over the two periods defined above, the numbers of notifications for each hazard category were compared (Table 14).

Table 14: Hazard Categories notified on RASFF: comparison of 5-year periods 2009-2013 and 2010-2014

Hazard Category	2009-2013	2010-2014	TREND: Increasing/Decreasing	Increasing/Decreasing %
Allergen	173	166	↓	-4
Composition	315	305	↓	-3
Food Additives & Flavourings	318	335	↑	5
Heavy Metals	99	113	↑	14
Industrial Contaminants	101	99	↓	-2
Mycotoxins	2610	2344	↓	-10
Approved Pesticides	928	1122	↑	21
Unauthorised Pesticides	885	922	↑	4
Legal Vet. Products	44	49	↑	11
Unauthorised Vet. Products	90	86	↓	-4
Prohibited Vet. Products	57	57	↔	0
Pathogenic Micro-Organisms	1739	1943	↑	12
Non Pathogenic Micro-Organisms	264	256	↓	-3
Parasitic Infestation	11	7	↓	-36

The highest increase of notifications from the periods 2009 - 2013 to 2010 - 2014 has been observed for approved pesticides, with notifications increasing by 21%. Heavy metals, pathogens and legal veterinary medicines notifications have risen by 14%, 12% and 11%, respectively, over this time. Parasitic infestation and mycotoxin notifications have dropped by 36% and 10%, respectively while no change has been observed for prohibited veterinary medicines. Figure 19 highlights the results graphically.

The number of notifications for product categories for these time periods was studied revealing that increased notifications had been issued for non-alcoholic beverages, food additives and flavourings, milk and milk products, fruit and vegetables, poultry meat and poultry meat products, meat and meat products (other than poultry), cereals and spices. No change was observed for alcoholic beverages, fats and oils and other food products. There were decreasing numbers of notifications for honey, oilseeds and other seeds, soups, broths sauces and condiments, peanuts and tree nuts, water, eggs and herbs. The results are detailed in Table 15 and Figure 20.

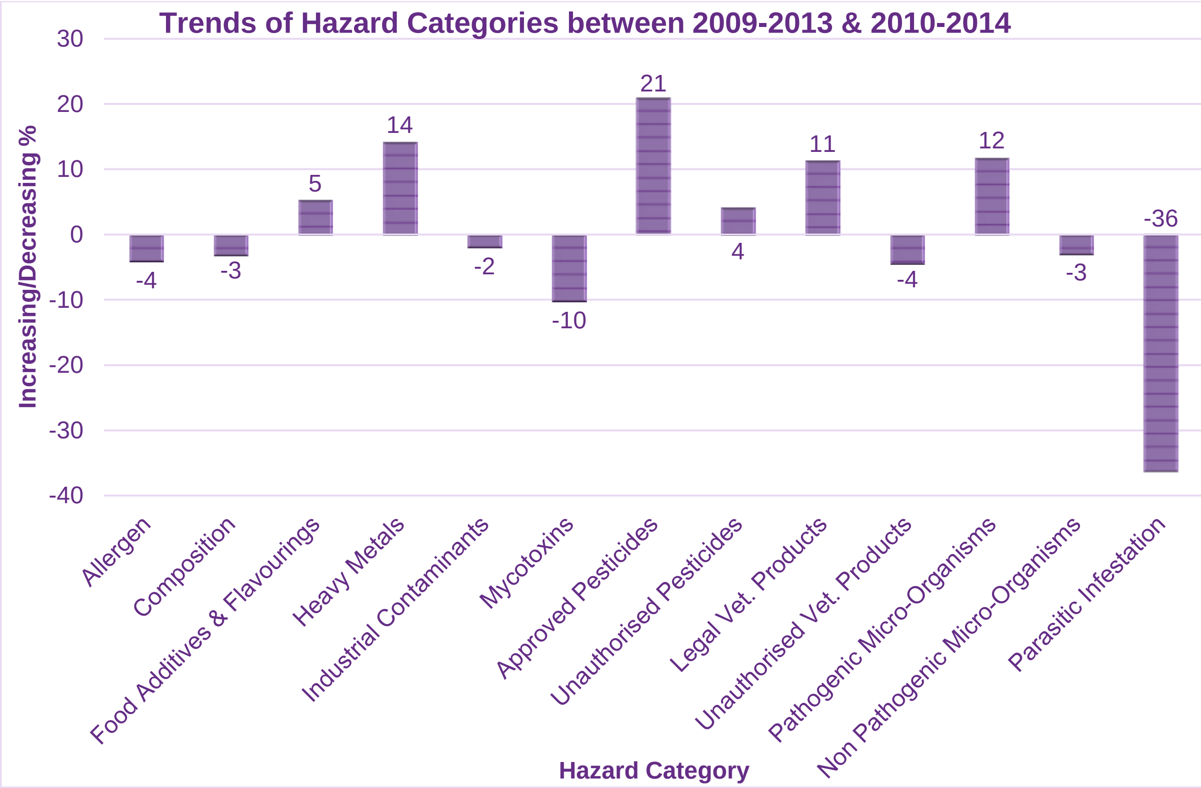


Figure 19: Trends of hazard categories between 2009-2013 and 2010-2014

Table 15: Product category notifications: comparison of 5-year periods 2009-2013 and 2010-2014

Food Category	2009-2013	2010-2014	Trend: Increasing/Decreasing	% Change
Alcoholic beverages	41	41	↔	0
Cereals	623	629	↑	1
Eggs	65	57	↓	-12
Fats and oils	77	77	↔	0
Food additives and flavourings	52	65	↑	25
Fruits and vegetables	2698	2996	↑	11
Herbs	590	578	↓	-2
Spices	526	532	↑	1
Honey	48	34	↓	-29
Meats and meat products (other than poultry)	829	855	↑	3
Milk and milk products	223	250	↑	12
Non-alcoholic beverages	42	57	↑	36
Peanuts and tree nuts	1777	1529	↓	-14
Oilseeds and other seeds (excluding oil)	468	378	↓	-19
Other Food products	29	29	↔	0
Poultry meat and poultry meat products	557	590	↑	6
Soups, broths, sauces and condiments	313	267	↓	-15
Water	39	34	↓	-13

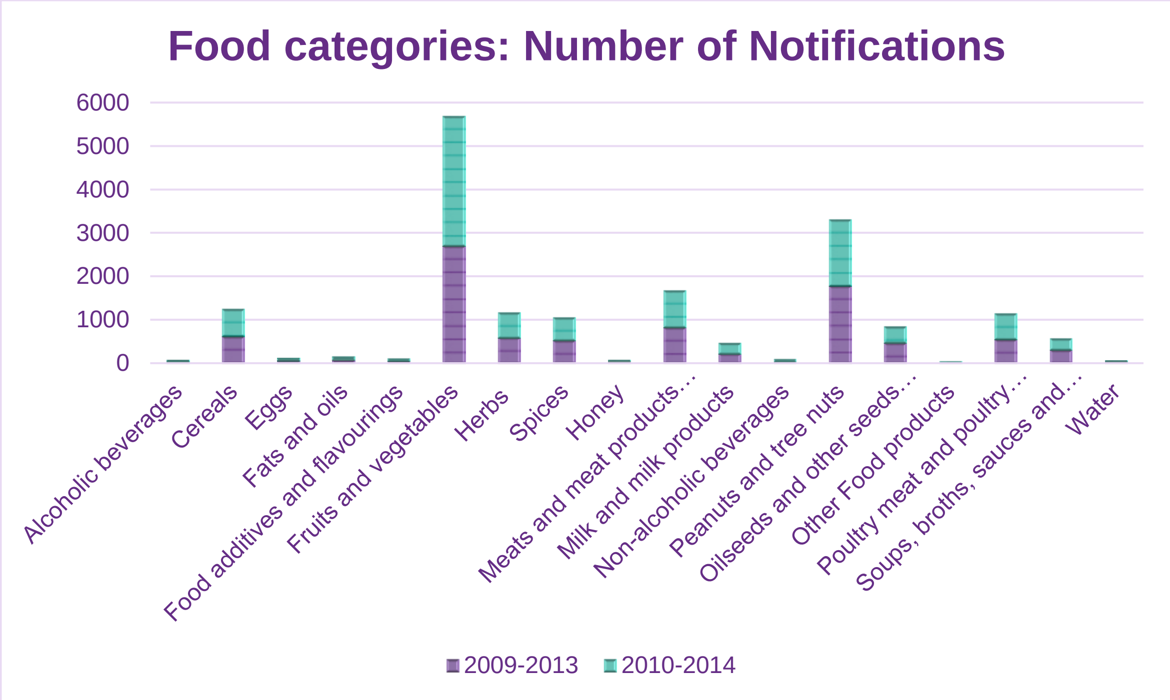


Figure 20: Number of notifications per product category over the period 2009-2013 and 2010-2014

Discussion

The FoodHazard Alert database has been constructed by downloading five years of RASFF alerts over the period 2009-2013. This information, coupled with company sensitive data, i.e. lists of raw materials/food ingredients have been categorised by commodity, exporting country and hazard. The likelihood of hazard occurrence has been calculated (by year) and a hazard severity score applied to each to enable priority testing recommendations to the industry. The observed results have revealed no revelations in terms of the hazards associated with particular food ingredients, for example the primary risk for meat, dairy and water commodities is pathogenic micro-organisms, while for cereals seeds and nuts it is mycotoxins/biotoxins. The database allows the user to interrogate the data further to identify secondary, tertiary and other risks related to their raw ingredients. Although the hazards are categorised into groups, the user may drill down into the data to pinpoint specific risks, e.g. which pathogenic micro-organisms pose the greatest threat or in the case of cereal contamination, which mycotoxins are notified regularly.

Testing schemes can therefore be prioritised to ensure that all raw ingredients/food materials used within the pork and poultry industry are safe for human consumption. Additionally when combined with information on the country of origin, companies will be able to select the safest source for their commodities. There were several hazard categories that did not fit within the developed scoring system and included Adulteration/Fraud, Chemical contamination (other), Foreign bodies, GMO & Novel Food and Labelling absent/incomplete/incorrect. On examination, these notifications did not present a food safety issue to the consumer. One example was the large number (87) of adulteration/fraud notifications in meat and meat products in 2013. This, we know, was due to the horse meat crisis.

Through increased testing and vigilance the number of notifications for 2014 fell significantly to 1 and this was unauthorised importation of meat. Although these notifications were not scored, the frequency of notifications is invaluable to the industry in bringing awareness of these additional hazards and enabling the introduction of schemes to mitigate for such problems.

By examining the notifications from the period 2009 to 2013 and comparing them with those from 2010 to 2014, trends in the data were analysed. Is a particular hazard increasing or decreasing over time? Are the numbers of notifications for a particular product category increasing or decreasing over time? This information may be valuable to the industry in prioritising testing.

6 Conclusions and recommendations

This study developed a risk ranking framework for the ranking of the major pathogens of concern in poultry produced on the island of Ireland[25]. The approach to risk ranking is based on established principles of food safety risk assessment which couples the probability of exposure to a hazard, the magnitude of the hazard in a food when present and the probability and severity of the outcome that might arise. The risk ranking framework culminated in the development of a risk ranking grid that summarized the occurrence of the major pathogens of interest in Irish produced poultry. Unlike other risk ranking approaches, the current approach does not explicitly give a scoring to the ranking. However, the risk ranking grid gives a visual summary to risk managers relating to the relative ranking of the hazards that allows them take appropriate risk management actions. By its nature, risk ranking should be dynamic, specific to the origin of the products being considered with an ongoing data gathering function to ensure the risk ranking process is kept up to date.

A comprehensive review of residue data sets for poultry and pork meat was carried out from different sources including Irish, EU and third country imports. In general, it was found that the residue risk was largely dependent on the source of the meat products. This is particularly the case with meat imported from outside of the EU because some drugs are used in these countries that are not licensed in the EU and thus have no EU maximum residues limits. The most important substances related to the poultry sector were antibacterial agents, anticoccidial and some banned veterinary drugs (chloramphenicol, nitrofurans and nitroimidazoles). The most important substances for the pork sector were steroids (in particular nandrolone), dioxins, banned veterinary drugs and licensed antibacterial agents. Sedatives/tranquilisers and quinoxalines were also identified as contentious residues for the pork sector. Advanced methodologies were applied to analyse residues in meat samples including methods for anticoccidials and beta-lactam residues. The results of these analyses showed that all of the tested samples were compliant. A high incidence of anticoccidial residues were detected in imported chicken with 25 of 54 samples containing residues but all were well below EU maximum residue limits.

The compositing of samples prior is an approach that can be used to scale up the number of samples tested and/or reduce analytical costs. In order for this approach to be feasible the analytical method being used should be capable of measuring residues to a quarter for the MRL, which would allow two samples to be composited. It ismore deirable that the composite sample is shipped to the laboratory rather than individual samples. Laboratories are generally staffed with very highly skilled scinetists and additional charges will be applied the additional sample compositing work. It is recommended that the analytical testing laboratory are consulted before starting a sample compositing program. Stability problems might be enountered with the analytes and/or the sample tissue in some circumstances, which may affect the analytical performance of the analytical method. Despite these complex problems, sample compositing can be feasible for many chemical contaminants and can be beneficial to the food industry. The disadvantage of the approach is that information will not be available for individual samples but this is not generally an issue when compliance or non-compliance information is required.

This project has created a risk identification and management system for products of pig and poultry origin produced on the ioI. The approach taken was to identify the hazards associated with particular raw materials/food ingredients, examine the frequency of the alerts and to calculate the associated risk by applying a food hazard score based upon a safety assessment of the hazard. The resultant ranking system enables these industries to make informed decisions on the testing priorities for specific ingredients, thus reducing the risks to both businesses and consumers alike. To protect the pork and poultry producers and processors on the ioI, it is imperative that the FoodHazard Alert database is implemented throughout the industry and is maintained in the long term.

7 Appendices

Appendix 1

How to prepare a composite sample:

Step 1: Prepare individual samples:

1. Collect samples (at least 100 g in weight) at slaughter plant.
2. Record key sample information, species, matrix, sex, breed, herd number, kill date, etc.
3. Record sampling information in a sample records book.
4. Homogenise individual meat samples in a food processor.
5. Transfer each sample to a separate sealed container or bags labelled with sample identification.
6. Store samples in a freezer at -20°C.
7. Wash the food processor with hot water between samples to prevent cross contamination.

Step 2: Preparation of composite sample

1. Weigh equal amounts of individual samples into suitable container to a give total weight of 100g.
2. Transfer the composite sample into a food processor and homogenise.
3. After homogenisation, transfer the sample into a sealed container or bag labelled with the composite sample identification.
4. Label the composite sample carefully with a unique I.D.., note the identification numbers of individual samples and record in a logbook.
5. Wash the food processor with hot water between samples to prevent cross contamination.
6. Store samples at -20°C.

Notes:

1. The number of samples used to form the composite sample will be based on the sensitivity of the analytical method.
2. The homogenisation time will need to be optimised carefully depending on the analyte and matrix.

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