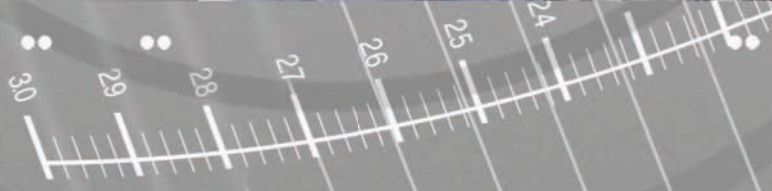


National Food Residue Database

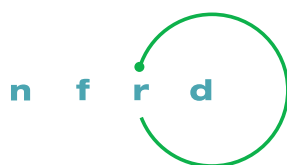
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National Food Residue Database

R E P O R T 2 0 0 9

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Acknowledgements

The financial assistance for the project provided by the Food Institutional Research Measure, Department of Agriculture, Fisheries and Food is gratefully acknowledged. The laboratories and agencies that contributed data to the NFRD are thanked for their cooperation with the project.

ISBN: 1-84170-546-2

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Introduction

CHAPTER ONE

1.1 Introduction to the NFRD

The National Food Residue Database (NFRD) is a comprehensive database for chemical residues and contaminants in food in Ireland. It is available to public access through the interactive website <http://nfrd.teagasc.ie>. The NFRD has been developed by the Residue Studies Group, Food Safety Department, Ashtown Food Research Centre, Teagasc within a research project funded by the Food Institutional Research Measure (FIRM), Department of Agriculture, Fisheries and Food.

Chemical residues in food, along with microbial pathogens, represent one of the principal determinants for the acceptability of food products to the consumer. Since the mid-1990's a considerable body of data has been developed on contaminant residues in food. However, much of these data are in individual reports or in formats not readily available to potential users. Development of the NFRD and interactive website provides a readily available single source for this information. The NFRD data are taken from monitoring and surveillance programmes and from studies and surveys on chemical residues and contaminants in food. The scope of the data includes studies carried out on veterinary drugs, prohibited substances, pesticides, radioactive substances, heavy metals, marine biotoxins, dioxins, PCBs and brominated flame retardants, mycotoxins, and other contaminants such as nitrates and PAHs.

To ensure the reliability of data in the NFRD, all data are assessed as being of an appropriate standard for inclusion. Data from the statutory monitoring programmes are subject to appropriate quality control and,

as such, meet the standard required. In the case of data from studies and surveys, the applied quality control, accredited status of methods used and other criteria are used to evaluate the suitability of the data.

To assist users in their interpretation of results contained on the database, an extensive library of information is accessible via the website, including details on regulations, specifications and norms relating to residues in food. This additional information increases the value of the residue data to the user, as the NFRD provides a single source of residue data in a co-ordinated and user-friendly format. Data for the NFRD is being provided by the various organisations and laboratories involved in contaminant residue analysis in Ireland. Such organisations include Teagasc (Ashtown Food Research Centre), Department of Agriculture, Fisheries and Food (Pesticide Control Service, Central Meat Control Laboratory), State Laboratory, Marine Institute, Environmental Protection Agency, Food Safety Authority of Ireland, Public Analyst's Laboratories, Universities and Institutes of Technology, and other agencies. The target audiences for the NFRD are:

- The Food Industry, for whom the data will provide information to assist the production, manufacturing and sale of Irish food,
- The Regulatory and Policy Agencies, for whom the data will provide information to support risk assessment activities and the development of regulations,
- The Public, for whom the data will provide information on the safety of the food supply.

1.2 The Database and Website

The NFRD is a public website that provides access to a database of scientific studies on chemical contaminants in food. Each residue study maintained in the database contains information on the test results generated from sample analysis as well as detailed background information necessary to interpret the test results.

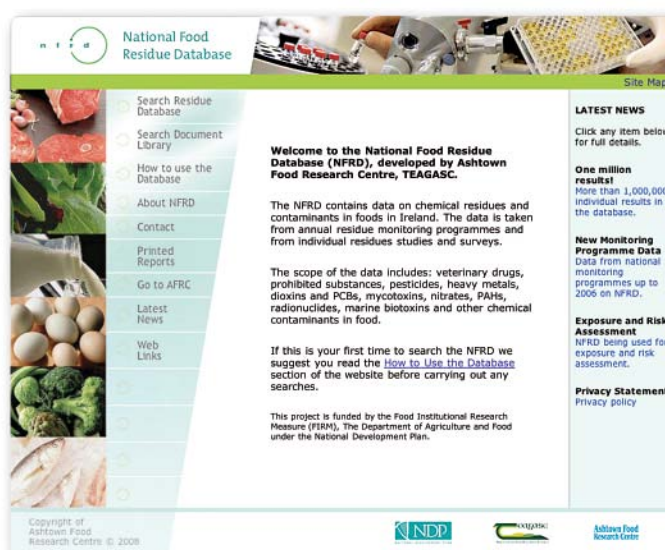
A detailed categorisation system for foods and residues has been implemented that ensures data integrity and provides an extensive search facility on the public website. Studies within the NFRD are categorised according to the type of study, the year the study was carried out and the agency responsible for the dataset. The category *Study Type* is divided into two sub categories: *Monitoring Programmes* and *Residue Studies and Surveys*. *Monitoring Programmes* relate to annual studies that are carried out in accordance with the requirements of National and European legislation. *Residue Studies and Surveys* relate to individual studies on chemical residues in food.

Foods and residues are classified in the database through a multi-level categorisation system. The food and residue coding system selected for the NFRD is modelled on the system previously developed for the KAP-Databank at RIKILT, Wageningen, The Netherlands. For the food coding system the NFRD uses three levels of categorisation: *Food Category*, *Food Sub Category* and *Food*. For classification of foods within the *Food Category*, the EU Classification of Food (Guidance Note No. 2 on the EU Classification of Food, Food Safety Authority of Ireland) is used. The residue coding system uses three levels of categorisation for a residue: *Residue Category*, *Residue Sub Category* and *Residue*.

The data recorded for a test result include: sample identification number, food sample, chemical residue, the analytical method used, the laboratory or agency responsible for the analysis, sample country of origin,

sampling date, whether a residue was detected in the sample and, where available, the concentration of residue found.

Data sets used to populate the NFRD are subject to a series of quality control processes both before and after initial data entry. This involves data validation on first receiving the data, in order to identify possible data entry errors or improbable values. Where necessary, the agency that supplied the data is contacted and any discrepancies are corrected. After data entry into the NFRD the application requires that all studies go through a review and approval phase before they may appear on the public website.



The public website is the interface through which the user may access scientific studies contained in the database. It is user-friendly, intuitive to use and conforms to the standards and recommendations set out by the World Wide Web Consortium (W3C). In addition to supplying a front-end search facility for the database, the public website provides access to a document library containing legislative and descriptive details on chemical residues associated with food. The main purpose in providing a document library facility is to ensure that the user has the

necessary information to correctly interpret the data displayed after a search of the database. Documents may be accessed through a keyword search or by following cross-reference links shown with the study results. To further assist the user in analysis of the data, a charting function has been incorporated into the NFRD. This provides the user with an option to supplement the residue results data with a chart or graph. Graphs are dynamically generated from the data, at the time they are requested.

1.3 The NFRD Report

Three previous reports **NFRD Report 2005**, **NFRD Report 2006** and **NFRD Report 2007/8** provided summaries of the data contained on the database in June 2005, June 2006 and October 2009, respectively. These reports covered the national residue monitoring programmes in the areas of foods of animal origin, fish, pesticides and radioactivity for periods of 5-8 years, data from the Food Residue Database 1995-2000 (Ashtown Food Research Centre, Teagasc), data on pesticides in food from studies by Bord Glas/Bord Bia and the FSAI, and data on dioxins and dioxin-like PCBs from a range of studies by the FSAI, EPA and Teagasc.

This fourth **NFRD Report 2009** provides a summary of the data contained on the database in June 2008, including data for additional years of the national residue monitoring programmes in the areas of foods of animal origin, fish, pesticides and radioactivity. Data on marine biotoxin monitoring in shellfish (in chapter 3) and on nitrates in leafy vegetables (in chapter 6) are included, as well as data on aflatoxins. Additional summary data on dioxins, dioxin-like PCBs, brominated flame retardants and PAHs from a range of studies by the FSAI, EPA and Teagasc are included in chapter 6.

The NFRD Report describes the content of the database, beginning in this chapter with some general information on chemical residues in food and on toxicology and regulation of the various

types of potential contaminants. In the following chapters of the **NFRD Report**, the major monitoring programmes and other residue studies and surveys are described and the results from these programmes and studies are summarised.

1.4 Chemical Residues in Food

Chemical residues are an important issue for food safety and for food manufacturing. A very broad range of chemical substances are potential contaminants in food, including veterinary drugs, feed additives and prohibited substances used on food-producing animals, pesticides used on plants and animals, environmental contaminants such as heavy metals, dioxins, PCBs, radionuclides, etc., and processing contaminants such as acrylamide, nitrate, semicarbazide, PAHs, etc. There may be multiple sources for some of these potential contaminants, such as pesticides in plant foods and in foods of animal origin via animal feedingstuffs, or nitrates from fertilizer usage or from detergents used in cleaning manufacturing plant and equipment. Considerable resources are devoted to research on chemical residues in food and to surveillance and testing activities. In Ireland, these activities are undertaken by statutory authorities, research institutes, academic institutions and public and private testing laboratories.

Veterinary drugs and feed additives

The major classes of veterinary drugs and feed additives include antimicrobials, antiparasitics and anticoccidials. **Antimicrobials**, commonly referred to as antibiotics, are widely used in conventional animal production to prevent and treat bacterial infection. The use of antimicrobials may be therapeutic, to treat infections in animals, prophylactic, to prevent the occurrence of infections, or as feed additives (limited, specific compounds) to improve performance. A broad range of antimicrobials are used in animal production including beta-lactams (penicillins, cephalosporins), tetracyclines,



sulphonamides, aminoglycosides and macrolides. There are a number of areas of particular concern with regard to use of antimicrobials in animal production. Firstly, residues of these substances may occur at unacceptable levels (above MRLs) in milk or edible tissues. Secondly, their widespread use in agriculture may contribute to the development of resistant strains of bacteria. Thirdly, residues of antimicrobials in milk may interfere with bacterial cultures used in the manufacture of fermented milk products, such as yogurts and cheese. Routine surveillance for antimicrobial residues in foods of animal origin indicates a relatively low but persistent incidence of positive samples, particularly in beef and pork meats. A particular potential exposure to antimicrobial residues in food of current interest is from honey. In recent years, honey imported into the EU from China has been found to contain residues of antimicrobials, including chloramphenicol, nitrofurans and streptomycin. This resulted in a restriction on importation of honey from China into the EU. Although there has been a reduction in the incidence of antimicrobial residues detected in imported honey, their use is still thought to be widespread.

There is an extensive number of **anthelmintics** (antiparasitic agents) licensed as veterinary drugs, such as the benzimidazoles, macrocyclic lactones and levamisole. Many of these drugs are licensed for the treatment of meat producing animals but not for dairy animals. Use of macrocyclic lactone drugs in fish farming is an issue of potential concern. Ivermectin was previously used in treatment for sea-lice in farmed salmon, on the basis that no other suitable product was available. In recent years, the drug emamectin benzoate (belonging to the same group of drugs as ivermectin) has been approved for use in fish farming.

Anticoccidials, or coccidiostats, are used in the treatment of coccidiosis, an infectious disease caused by microscopic protozoan parasites, which damage the intestinal tract

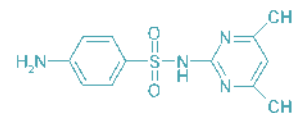
of poultry and other animals reared under intensive farming conditions. Poultry are treated routinely with anticoccidials, provided as additives in medicated feed early in the life of the birds. Subsequent feed is required to be free of anticoccidials to ensure residue-free poultry meat and eggs. Anticoccidial residues in poultry products may occur due to contamination of finisher feed at feedmills or due to poor feed control practices on farm. Results from the monitoring programme for anticoccidials in poultry liver, meat and eggs have revealed a high incidence of nicarbazin contamination in domestic poultry liver. Lasalocid is found in some liver samples at high levels. Nicarbazin and lasalocid residues may be detected also in some egg samples.

Prohibited substances

This category of chemical residues covers those substances that are banned for use in food-producing animals [Council Directives 96/22/EC and 96/23/EC], primarily growth-promoting hormones, beta-agonists and certain antimicrobials and other animal drugs. Problems with abuse of **growth-promoting hormones** was an important issue for beef produced in Ireland in the 1980s and, subsequently, abuse of **beta-agonists** occurred in the 1990s. Rigorous legislative and testing initiatives have resulted in an improved situation, relative to some other European countries. An ambitious programme of extensive testing of bile using automated immunoassay analysis (by the company Enfer Scientific) was used to control illicit use of beta-agonists. In the years 1998, 1999 and 2000, there were 40,000, 39,000 and 28,000 samples, respectively, tested for beta-agonists. Fifteen samples were found to be positive in 1998 but no positive samples were found in 1999 and 2000.

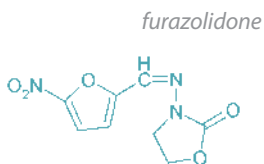
In the area of **banned antimicrobials**, scientists on the island of Ireland have made a major contribution to European science and control systems for nitrofurans antimicrobials, through the Fifth Framework

sulphamethazine



FoodBRAND project (2001-2004) [www.afsni.ac.uk/foodbrand/]. The occurrence of protein-bound metabolites of nitrofurans as persistent and potentially toxic residues in edible tissues resulted in their prohibition (Commission Regulation (EC) 1442/95). During 2002-2003 EU inspection laboratories reported finding nitrofuran metabolite residues in various food products from a number of countries, including:

- Asian aquaculture
- Asian and Brazilian poultry
- Portuguese poultry
- Other products – residues of nitrofurans have also been detected in a range of other animal derived-products (e.g. egg powders, rabbit meat, milk powders, hog casings) across the globe, including honey from a number of European countries.



These findings led to a requirement for testing of imports from designated countries (Commission Decisions 2001/699/EC, 2002/249, 250, 251/EC, 2002/794/EC, 2004/198/EC). The FoodBRAND project, with VSD/QUB (co-ordinator) and AFRC as partners with other European laboratories, was responsible for development of methods which were used by laboratories throughout Europe for control of imports.

Pesticides

Pesticides, including fungicides, herbicides and insecticides, are very widely used in crop production, and some insecticides may be used directly on food-producing animals. Exposure of humans to residues of pesticides is primarily through fruit, vegetables and cereals but may also occur through foods of animal origin, normally via contaminated animal feedingstuffs. Under surveillance programmes conducted by the Pesticide Control Service, Department of Agriculture, Fisheries and Food (www.pcs.agriculture.gov.ie), domestic and imported foods are tested for broad classes of pesticides. Results of testing indicate that residues of pesticides are not detectable in over 60% of tested produce while in the approximately 40% of

residue-positive samples, most pesticides are at levels below the statutory limits. Pesticide residues at levels above the MRLs occur in a few percentage of samples tested, primarily fruit and vegetables. In some cases, pesticides may be found in samples of produce for which the particular substance has not been approved for use. Where unapproved pesticide residues or approved pesticide residues at levels above MRLs are determined in produce, these occurrences are investigated and repeat testing of consignments of samples from the same source/region are undertaken.

Biotoxins

Biotoxins covers that broad range of toxic substances produced by fungi (mycotoxins), phytoplankton (phycotoxins) and plants (anti-nutritional substances).

Mycotoxins may be produced by certain fungi (*Aspergillus*, *Penicillium*, *Fusarium*) under particular conditions, both on plants during growth and in stored plant materials post-harvest. Mycotoxins may be highly toxic and are of concern both in human food and animal feed. The occurrence of mycotoxins in plant-based foods, such as cereals, nuts, fruit, is dependent on growth and storage conditions of the crop. Some of the principal mycotoxins of concern are aflatoxins (B1, B2, G1, G2) in foods such as nuts, dried fruit, spices and corn, and the metabolite aflatoxin M1 in milk and dairy products, ochratoxin A in cereals, coffee and beverages, zearalenone and trichothecenes in cereals, and patulin in apple products.

Maximum levels have been set by EU legislation for the mycotoxins aflatoxins, ochratoxin A, patulin and *Fusarium* toxins (Commission Regulation 1881/2006 and amending regulation 1126/2007). Substantially lower maximum levels have been set for mycotoxins in foods for infants and children, reflecting the chronic toxicity of these substances. Sampling of food commodities to obtain a representative sample is particularly difficult for mycotoxins because of uneven distribution of the mycotoxins in the crop or

bulk food. Provisions for sampling and analysis are covered by Commission Regulation 401/2006. In addition, there are a number of Commission Recommendations (2003/598, 2006/583) on prevention and reduction of patulin and *Fusarium* toxins, respectively, in certain foodstuffs, and Commission Decisions (2006/504, 2007/549, 2007/563, 2008/47) on special measures relating to aflatoxins in certain imported foodstuffs

Phycotoxins, produced by many different species of phytoplankton, are grouped according to their toxic effects, such as paralytic (PSP) toxins (e.g. saxitoxin), diarrhetic (DSP) toxins (e.g. okadaic acid), amnesic (ASP) toxins (e.g. domoic acid) and other toxins, such as azaspiracid. Phycotoxins, where present, may accumulate in filter-feeding shellfish such as mussels, scallops, oysters and clams. Because of the acute toxic effects caused by phycotoxins, European legislation has established maximum levels for certain of these toxins in edible tissue; Regulation 853/2004 of the European Parliament and Council specifies 800 µg/kg for PSP toxins, 20 mg/kg for the ASP toxin, domoic acid, 160 µg/kg for DSP toxins, as okadaic acid, 1 mg/kg for yessotoxin, and 160 µg/kg for azaspiracid. The mouse bioassay was the recognised standard method for establishing whether shellfish are suitable for human consumption. However, there have been considerable advances, both for screening and confirmatory tests, directed at replacing the bioassay with definitive, quantitative analytical methods, such as liquid chromatography-mass spectrometry

Environmental Contaminants

Environmental contaminants, such as dioxins, polychlorinated biphenyls (PCBs), nitrates, radionuclides, etc., have been responsible for a number of food scares over the last decade. Arising from a number of incidences involving **dioxins and PCBs**, the European Union has set maximum permissible levels in foods of animal origin, including fish, and animal and vegetable oils and fats (Commission Regulation 1881/2006). In the late 1990s, there

were a number of serious incidences of dioxin contamination in food, for example (a) dioxin-contaminated citrus pulp from Brazil in 1998, which was used in feed for dairy animals in France and resulted in contaminated milk, and (b) gross contamination of waste edible oil with machine oil in Belgium in 1999, resulting in contaminated feed and contaminated food products such as poultry, eggs, red meat and milk. A number of countries, including The Netherlands and the United Kingdom, previously reported relatively high dioxin levels in eggs, particularly in free-range eggs. This was attributed to foraging of chickens on dioxin-contaminated land and resulted in the European Commission extending the transition period for compliance with the specified maximum level of 3 pg TEQ/g fat for eggs, now confirmed by regulation 1881/2006. The specified maximum levels for dioxins in various foods range from 1 to 6 pg TEQ/g fat; maximum levels for the sum of dioxins and dioxin-like PCBs have been set and range from 1.5 to 12 pg TEQ/g fat for various foods. The European Commission have issued recommendations on reducing the presence of dioxins and PCBs in feedingstuffs and foodstuffs (2006/88) and on monitoring of background levels of dioxins and PCBs (2006/794).

Nitrate at excessive levels in leafy vegetables is a particular problem in many European countries including Ireland. Use of nitrogen fertilizers in farming is the likely source of much of the excessive levels in vegetables. Maximum levels have been set for nitrate in lettuce, spinach and foods for infants and children [Commission Regulation 1881/2006]. Annual monitoring of nitrate in leafy vegetables (lettuce, spinach and cabbage) [State Laboratory Annual Report 2006, at www.statelab.ie] show that the maximum levels for nitrates are exceeded in some samples. Previously, a particular additional source of excessive nitrate had been linked to milk powder manufacturing, and this is of particular concern for infant formula to which relatively low maximum





levels apply. The cause of excessive nitrate in milk powders seems to be related to use of nitric acid based cleaning systems.

Radionuclides may occur in food due to the radioactivity that is present in the environment through natural processes, the testing of nuclear weapons in the atmosphere, accidents (such as at the Chernobyl power plant), reprocessing of nuclear fuel (such as at Sellafield and La Hague) and the routine discharge of radionuclides from nuclear installations. Testing by the Radiological Protection Institute of Ireland of air, water, food and samples from the marine environment indicate that levels of radionuclides generally are relatively low and are within any legal requirements [www.rpii.ie].

Heavy Metals

Heavy metals are contaminants that may occur as residues in food from the environment/industrial activities or from food processing. Maximum levels are set for heavy metals in foodstuffs (Commission Regulation 1881/2006, amended by Commission Regulation 629/2008), in particular, for lead and cadmium in a broad range of animal, fish and plant foodstuffs, for mercury in fish and shellfish and for tin in canned foods, baby foods and beverages. Provisions for sampling and analysis for the official control of these maximum levels for heavy metals in foodstuffs have been set in Commission Regulation 333/2007. Fish and shellfish may be vulnerable to potentially higher exposure to heavy metals than farm animals and so are subject to particularly intensive survey. For example, the Marine Institute studies the bioaccumulation of heavy metals in shellfish and finfish and the levels in marine sediments, including the trace metals; mercury, cadmium, lead, copper, chromium, zinc, nickel, silver and total arsenic. The Public Analyst's Laboratories undertake testing of a broad range of food types for heavy metals, covering both surveys of food at retail level and targeted studies of particular food types. Surveillance for residues of heavy metals in foods of animal origin is specified in Council Directive 96/23/EC. Testing

for heavy metals has not indicated a problem with non-compliant samples in Ireland.

Processing Contaminants

Processing contaminants refer to chemical substances produced in food during food manufacturing, cooking, packaging and other processing activities. Some examples of such contaminants are nitrosamines, polycyclic aromatic hydrocarbons (PAHs), acrylamide and semicarbazide.

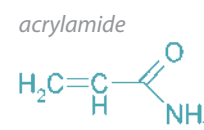
There are a number of sources for **nitrosamines** in food, including (a) occurring directly from materials coming into contact with food - such as, for example, elastomer or rubber teats used by infants and rubberised netting used in processing of cooked meats - and (b) forming in food from nitrate/nitrite during cooking/processing [www.fsai.ie]. Nitrosamines are a class of chemical compounds that have been found to be carcinogenic in a wide variety of experimental animals. In the early 1970's liver disorders and cancer were observed to occur in farm animals in Norway. This effect was linked to the inclusion in the animal feed of fish meal that had been preserved with relatively large amounts of sodium nitrite. The nitrosamine, N-nitrosodimethylamine, was found in the fish meal and had been produced by a chemical reaction between a naturally-occurring amine, dimethylamine, in the fish meal and sodium nitrite. Because amines occur commonly in foods, there was concern about nitrosamine formation in cured foods, such as meat, treated with sodium nitrite (to control *Clostridium botulinum*). It was found that cured meats contained nitrosamines and this led to lower limits being placed on the amount of sodium nitrite permitted in the curing process. Overcooking of meat products cured with nitrite is known to result in the production of nitrosamines. It is thought to be possible, also, that nitrosamines might be produced during digestion of foods in the human stomach where there is a source of nitrate/nitrite and amines, which are natural breakdown products of proteins. Therefore, maximum levels have been set for nitrate

in leafy vegetables (Commission Regulation 1881/2006), for nitrate/nitrite in cured meats and for nitrosamines in food contact materials. Polycyclic aromatic hydrocarbons, **PAHs**, are contaminants which may occur in the environment as products of incomplete combustion, for example from incinerators, or from food processing operations involving heating or smoking, particularly of meat. These compounds may be carcinogenic and studies on residues in food often concentrate on measuring levels of the most common carcinogenic PAH, benzo[a]pyrene, using it as an indicator for contamination of food products with PAHs. Published reports on benzo[a]pyrene in meat products indicate levels ranging from less than 0.1 to 4 ppb. A problem with PAHs in olive oil (pomace oil) was identified by way of Food Alert Notifications in 2001 and the Public Analyst's Laboratory in Galway undertook extensive monitoring of various oils during 2002. The results of this surveillance activity showed that 9 (of 66) samples of Evening Primrose Oil contained benzo[a]pyrene above the limit of 2 µg/kg, with levels ranging between 3 and 59 µg/kg. The other oils (86 samples) all complied with the limit for benzo[a]pyrene of 2 µg/kg (Commission Regulation 1881/2006). Further extensive testing for benzo[a]pyrene in food products was undertaken in 2003 and 2004; of 282 and 84 samples tested only 4 and 2 fish/fish oil samples, respectively, contained levels above the limit of 2 µg/kg (ranging from 2.8 to 6.6 µg/kg, with one sample – resulting from an EU Alert Notification – at 80 µg/kg).

Acrylamide was identified as a contaminant of concern from work undertaken by the Swedish National Food Administration in 2002. Acrylamide may occur at high levels in fried, oven-baked and deep-fried potato and cereal products. Acrylamide has been shown to be carcinogenic and to be a neurotoxin and genotoxin in test animals, but there is no definitive evidence, from epidemiological studies, for such effects in humans. The Public Analyst's Laboratories have carried out surveys on the content of

acrylamide in susceptible processed foods. Acrylamide may also be generated in home cooking. A research project at Ashtown Food Research Centre has examined the factors influencing the formation of acrylamide in potato food products, including asparagine and reducing sugars in different cultivars and storage and cooking conditions (*Acrylamide Formation in Potato Products, Teagasc 2006, ISBN 1 84170 469 1*). The food industry in Europe has developed voluntary measures to help producers and processors identify ways to lower acrylamide in food products and the Commission has recommended to Member States a programme for monitoring acrylamide levels in a wide range of foodstuffs on an annual basis in 2007, 2008 and 2009 (Commission Recommendation 2007/331).

Semicarbazide has been identified as a food safety issue, particularly in foods packed in glass jars with metal lids sealed with plastic (PVC) gaskets. Semicarbazide, a carcinogen and genotoxin in test animals, is thought to occur as a breakdown product of azodicarbonamide, a "blowing agent" used to make a foamed plastic which is suitable for gaskets. Azodicarbonamide is used, also, in some non-EU countries for treatment of flour used in bread-making, and other potential sources of semicarbazide have been identified. The food industry reported finding levels up to 20 ppb in food (levels of 1-7 ppm semicarbazide have been detected in the gaskets themselves). The presence of semicarbazide in these foods is of particular concern because many baby foods are packaged in such jars. However, a risk assessment organised by the European Food Safety Authority has indicated that there is no reason for consumers, including infants, to change their dietary habits especially because of the strong protection given by such packaging against microbiological risk. Meanwhile, the European food industry is looking at ways, including alternative "blowing agents" to azodicarbonamide, to reduce or eliminate semicarbazide from these food products.



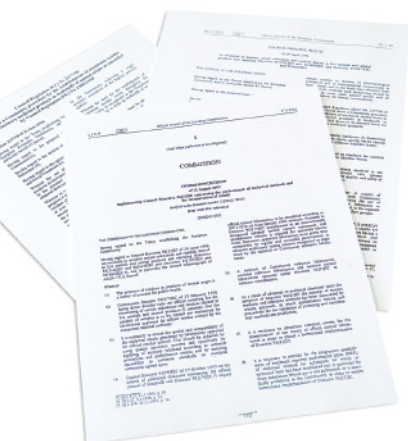
1.5 Toxicology of Residues in Food

The interpretation of data on residues in food is made against residue limits set by regulatory bodies. In the Irish context most of the residue limits specified in national regulations are derived from European regulations. Depending on the particular category of chemical substance concerned, the maximum permitted level of residue in a food commodity is described as a maximum residue limit (for veterinary drugs, pesticides, etc.) or a maximum level (for mycotoxins, dioxins, heavy metals, etc.). While the maximum residue limit/maximum level represents that level of a potentially hazardous substance that is allowed in food, a fundamental principle of EU legislation on contaminants in food is that the level should be kept as low as can reasonably be achieved using good working practices. Such good working practices include good agricultural practice (GAP) relating to pesticide usage, good veterinary practice (GVP) relating to use of veterinary drugs, and good manufacturing practice (GMP) relating to control of contaminants in food product manufacturing. Where a maximum residue limit/maximum level is not set by regulation, an action limit (or level) may be applied - i.e. a level of residue in a sample leading to actions such as declaration of the sample as 'non-compliant', initiation of an investigation, removal of food from the market, etc. Action limits/levels are applied, in the case of residues of prohibited substances, to results from testing of samples not normally consumed as food, such as urine, and for certain categories of substances, such as feed additives. For ease of use, all reference to regulatory maximum residue limits/maximum levels in this report are referred to as MRLs.

In the case of licensed veterinary drugs and pesticides, the Acceptable Daily Intake (ADI) is a critical value. The ADI is an estimate of the amount of a chemical substance that may be ingested over a lifetime without appreciable risk to health. ADI values are derived from the No Observed Adverse Effect Level (NOAEL) determined from a range of

toxicity tests, usually on animals. These tests include acute and repeated dose toxicity, genotoxic, carcinogenic and reproductive/developmental toxicity, pharmacodynamic and pharmacokinetic tests, and neurotoxicity, immunotoxicity and antimicrobial activity tests. From such tests a NOAEL is determined and is divided further by a safety factor, usually 10-1000, which takes account of possible differences between the test animals and humans, and possible enhanced toxic effects on susceptible individuals, infants and children and the elderly. The NOAEL, corrected for the safety factor, is the ADI, expressed as μg substance per kg bodyweight per day. The ADI for a substance is divided across the different foods contained in a theoretical daily diet and this quantity is designated as the MRL for that food, expressed as μg substance per kg food. In this way, MRLs are based on the possible occurrence of residues of the substance in all foods in the diet on a particular day without exceeding the ADI.

In the case of pesticides, MRLs are based on GAP and represent that concentration of a pesticide residue likely to occur in a crop following correct usage of the pesticide to achieve eradication of the pest. An MRL determined in this way for a pesticide must not have the effect of causing the ADI to be exceeded. In the case of a veterinary drug, a withdrawal period is specified which represents the length of time after the end of treatment before the animal may be used for food to ensure that any residues in edible tissues will have depleted to below the MRL. Withdrawal periods are specified for licensed veterinary drugs and feed additives and adherence to the withdrawal period represents GVP. In the case of natural (e.g. mycotoxin), industrial (e.g. dioxin) or process (e.g. nitrate) contaminants, the MRLs are based on toxicity and what levels may be achievable in foods under good working conditions.



Monitoring Programme for Foods of Animal Origin

CHAPTER TWO

2.1 Introduction

On an annual basis, foods of animal origin are monitored for the presence of residues of prohibited substances, veterinary drugs, feed additives, pesticides, heavy metals, mycotoxins and other contaminants. A "Residue Testing Plan for Ireland" is developed each year in accordance with Council Directive 96/23/EC on "measures to monitor certain substances and residues thereof in live animals and animal products". In consultation with the Food Safety Authority of Ireland (FSAI), the Department of Agriculture, Fisheries and Food (DAFF) develops the residue plan for each year and is responsible for overall co-ordination of the plan.

Council Directive 96/23/EC specifies, inter alia, the submission of the residue plan and subsequent results of testing to the European Commission, the substances and groups of residues to be monitored (Annex 1), the species of animal in which each substance/group of substances is to be monitored (Annex II), the targeted sampling strategy to be used (Annex III), the sampling levels and frequency to be applied (Annex IV), and the official control measures and actions to be taken in the case of non-compliant results or other infringements occurring. A body of European and national legislation regulates the prohibition or authorisation, distribution and placing on the market and rules governing the administration of the substances listed in Annex I to Council Directive 96/23/EC.

The Department of Agriculture, Fisheries and Food manages the various measures connected with implementation of the residue plan. Department veterinary staff, based in the export approved slaughtering plants, implement the controls (inspections, taking of samples) in

relation to the plan in such plants. Controls at farm level are implemented by DAFF staff, based at the District Veterinary Offices (DVOs) distributed throughout the country. A centrally based DAFF specialist unit conducts focused investigations, in co-operation, as appropriate, with staff in the slaughtering plants and/or DVOs and also the police and customs services

Laboratories are formally designated by DAFF to undertake testing of samples taken under the plan for residues. Each laboratory is approved to perform specific tests, screening and confirmatory, for specific substances or groups of substances. The approved laboratories are required to perform residue testing at the appropriate standard, including use of accredited methods, to ensure the accuracy of test results. Certain of the approved laboratories are designated as National Reference Laboratories for specific substances and have additional responsibilities relating to co-ordination of testing, comparative testing between laboratories, involvement with European Commission organised training and dissemination of information from the Community Reference Laboratories. The designated National Reference Laboratories and the substances for which they have responsibility are shown in Table 2.4.

Where the presence of banned substances is found in live animals or food products, or residues of permitted substances are found in food products at levels above the appropriate MRL or other limit, specified measures are taken. In each instance where a sample taken from an animal or carcass is found to be non-compliant, an investigation is carried out to ascertain the origin of the animal/carcass and the cause of the illegal administration or incorrect usage, as



well as the origin of any product illegally used. Testing of samples from live animals, generally, is to monitor for use of banned substances. When a sample is taken from a live animal, that animal is identified and marked. In the event that an analytical result is non-compliant, a permanent mark is placed on the animal and an official order served, the effect of which is to prohibit, inter alia, the movement of the animal or its entry into the food chain.

Table 2.1 Listing of substances to be included in the Residue Plan

GROUP A - Substances having anabolic effect and unauthorised substances	
A1	Stilbenes, stilbene derivatives, and their salts and esters
A2	Antithyroid agents
A3	Steroids, including both natural hormones and synthetic steroids
A4	Resorcylic acid lactones, including zeranol
A5	Beta-agonists
A6	Compounds included in Annex IV to Council regulation (EEC No 2377/90 of 26 June 1990 (e.g. chloramphenicol, nitrofurans, nitroimidazoles, sedatives, etc.)
GROUP B - Veterinary drugs (1) and contaminants	
B1	Antibacterial substances, including sulphonamides, quinolones
B2a	Anthelmintics
B2b	Anticoccidials
B2c	Carbamates and pyrethroids
B2d	Sedatives
B2e	Non-steroidal anti-inflammatory drugs (NSAIDs)
B2f	Other pharmacologically active substances (e.g. carbadox, dexamethasone)
B3a	Organochlorine compounds, including PCBs
B3b	Organophosphorus compounds
B3c	Chemical elements (e.g. lead, cadmium, mercury, arsenic)
B3d	Mycotoxins (e.g. ochratoxin A, aflatoxin M1)
B3e	Dyes (e.g. malachite green)
B3f	Others

(1) Includes unlicensed substances that could be used for veterinary purposes

Authorised officers of the Department are empowered under the legislation to condemn animals where tests reveal the presence of unauthorised substances, or residues of authorised substances in excess of MRLs. Where evidence would support a prosecution a file is prepared and criminal proceedings are instituted against any person involved in the administration of substances to an animal contrary to law.

Where products associated with use of banned substances are found, such products are

also investigated. The products involved are veterinary medicines, animal feed (including drink) and equipment for the manufacture or administration of veterinary medicines. All such items are seized and detained under the Animal Remedies Act, 1993 (as amended by the Irish Medicines Board (Miscellaneous Provisions) Act 2006) and held in official custody. Such products, or samples thereof, are subjected to analysis and, in the event of a positive finding, criminal proceedings may be instituted against the person(s) concerned. On completion of Court proceedings, products are forfeited and subsequently destroyed

Where banned substances are found from the monitoring programme to have been present in food products, including carcasses, or where levels of permitted substances are found to be above the appropriate MRL or other limits, the investigation may involve further testing of suspect carcasses from the same or related sources. In those cases, the carcasses are detained pending analysis. In the event of a non-compliant result, the carcass in question is declared unfit for human consumption, denatured and destroyed. Where evidence would support a prosecution, a file is prepared and legal proceedings are instituted against any person involved in the administration of substances to an animal contrary to law.

2.2 Sampling and Analysis

The substances for which testing is required to be undertaken in the residue plan are specified by Council Directive 96/23/EC (Annex I) as Group A - substances having anabolic effect (i.e. growth promoting agents) and unauthorised substances (e.g. prohibited antimicrobials and other drugs), and as Group B - veterinary drugs and contaminants (Table 2.1). The species of animals, and their products, for which sampling and analysis for the different substances must be included in the residue plan are specified in Annex II of 96/23/EC (Table 2.2). This latter classification is aimed at targeting sampling and analysis towards animal species and their products where specific substances are more likely to occur.

The sampling strategy to be used in the Residue Plan is specified also in Council

Directive 96/23/EC (Annex III) and Commission Decisions 97/747/EC and 98/179/EC. In summary, the residue plan is aimed at surveying and revealing the reasons for residue hazards in foods of animal origin. For the Group A substances, the monitoring is aimed at detecting the illegal administration of prohibited substances. For the Group B substances, the monitoring is aimed at controlling the compliance with MRLs (veterinary drugs, pesticides, mycotoxins, heavy metals, etc.) and monitoring the concentration of environmental contaminants. In all cases, sampling is targeted (rather than random) taking into account criteria such as sex, age and species of animal, production system in use and all evidence of misuse or abuse of substances. Sampling is required to be unforeseen, unexpected and to be undertaken at no fixed time and on no particular day of the week

The sampling levels and frequencies are specified by Council Directive 96/23/EC for each species of animal (Annex IV). The minimum number of samples to be taken for each species is a defined percentage of the number of animals slaughtered in the previous year (in the case of bovine, porcine, ovine, equine and caprine animals) or related to the production (tonnes) for poultry, milk, eggs and honey. The residue plan provides for much more extensive sampling for certain species and substances, such as antimicrobial substances in pigs/pork, where experience has indicated that there may be a cause for concern. Within each species of animal, the proportions of samples to be tested for group A, group B1, group B2 and group B3 substances are specified. In the case of group A substances for bovine, porcine and poultry species, a defined proportion of samples are taken from live animals on farm. Since slaughter numbers and production vary little from year to year, the summary breakdown of samples for the 2007 Residue Plan (Table 2.3) gives a representative indication of the distribution of samples for each year. The designated numbers of samples for each species/food and substance group are divided between the various slaughtering plants (in proportion to throughput of animals) and, for

on-farm samples, between the various DVOs (in proportion to animal population in each DVO region). The annual sample numbers for each slaughtering plant/DVO are divided into quarterly quotas of samples to ensure an appropriate spread of sampling over each year.

All samples taken for the Residue Plan are defined as "official samples" and these are taken by authorised persons according to specified rules for sampling. In general, official samples are taken by authorised persons, placed in suitable sealed containers, identified by a unique number and a record of the sample details and of all persons having custody of the sample is maintained (the Sample Report Form). The rules are designed to ensure that the source and identity of the sample is accurate, that contamination of the sample does not occur and that the sample is provided to the testing laboratory in a condition suitable for testing for the designated residue. This assurance is necessary to allow for subsequent actions, including criminal proceedings, to

Table 2.2 Species of animal and food products required to be tested for the various substances included in the Residue Plan

Substance groups	Bovine ovine, caprine, equine animals	Poultry	Aquaculture Animals	Milk	Eggs	Rabbit meat and the meat of wild (*) game and farmed game	Honey
A1	•	•	•			•	
A2	•	•				•	
A3	•	•	•			•	
A4	•	•				•	
A5	•	•				•	
A6	•	•	•	•	•	•	
B1	•	•	•	•	•	•	•
B2a	•	•	•	•		•	
B2b	•	•			•	•	
B2c	•	•				•	•
B2d	•						
B2e	•	•		•		•	
B2f	•		•				
B3a	•	•	•	•	•	•	•
B3b	•			•			•
B3c	•	•	•	•		•	•
B3d	•	•	•	•			
B3e			•				
B3f							

(*) Only chemical elements are relevant where wild game is concerned.

Table 2.3 Breakdown of samples by Substance Group and Species/Food for Residue Plan, 2008

	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farmed	Wild	Farmed	Wild			Farmed	Slaughter	Farmed	Wild			
Production in 2007:	1,682,878 animals		2,588,761 animals		2,965,844 animals	1,381 animals	139,822 tonne		45.1 tonne	105.5 tonne	4.93 m tonne	33,688 tonne	140 tonne
Samples, minimum required:	6,732		1,295		1,483		978		100	100	329	200	10
Residue Plan:	7,655		11,559		1,995	237	131		20	100	1,152	250	118
Sampling Point:	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Farm	Product
Total, Group A:	2,157	2,266	52	629	490	68	120	475	19		365	108	20
A1	116	117	7	54	21	5	18	56	2				
A2	116	133	9	33	28	5	16	20	2				
A3	821	767	17	161	119	7	13	30	1		94		
A4	147	161	6	39	73	3	18	54	2				
A5	529	608	5	98	113	20	19	49	6				
A6	428	480	8	243	257	15	33	239	6		271	108	20
Total, Group B:	102	7,353	25	12,625	1,596	182		785	92	103	878	194	100
B1		5,867		11,926	896	43		355	10		269	126	30
B2a		598		142	257	28		88	13		278		
B2b		120		29	75	5		204	13			55	
B2c		102		38	56	15		35	11				20
B2d		82		100	52	21							
B2e	102	82	25	29	42	40		16	4		89		
B2f		98		176	48	10					78		
B3a		149		98	46	4		24	12		72	13	10
B3b		60		32	40	4					46		20
B3c		158		41	68	8		56	29	103	63		10
B3d		37		14	16	4		23			72		10



be taken where a non-compliant result is obtained. The samples are sent to the testing laboratory designated to undertake official testing for the substances for which the samples were taken. Table 2.4 gives a general summary of the categories of testing undertaken by the laboratories approved for the Residue Plan; this summary reflects the situation in 2007 but may change. Analyses may be by screening tests - relatively simple, rapid techniques to clear compliant samples and to identify possible non-compliant samples for further testing, or by confirmatory tests - definitive techniques that identify the residue present and usually measure the concentration. Screening tests include immunoassays (Group A substances), inhibitory substance testing (Group B1 substances) and chromatographic techniques such as high performance liquid chromatography (HPLC) and gas chromatography (GC). In the case of Group A substances, the confirmatory tests are based on mass spectrometry, GC-MS or LC-MS/MS. In the case of Group B substances, the confirmatory tests are chromatographic

techniques including HPLC, GC-ECD, GC-FPD, GC-MS and LC-MS/MS, except for group B3(c) for which testing is performed by atomic absorption spectrophotometry. For many Group B2 and B3 substances, the same techniques are used for screening and confirmatory testing. The approved laboratories apply quality control programmes to their analytical testing to ensure the accuracy of the results obtained and use validated methods, according to EC guidelines, and participate in proficiency schemes and inter-laboratory studies. The approved laboratories are expected to have their tests accredited to the ISO 17025 standard.

2.3 Results

Summary data for the results of the Residue Plan for the years 1998 to 2008 are provided in Tables 2.5 to 2.15. In considering the results of monitoring for each year it is important to be aware that the number and/or type of samples of a particular species/food taken for each group may have varied, that the range of substances tested for within a group may have

changed, that the specificity and sensitivity of techniques used may have changed, and that other factors may influence the comparability of results from year to year.

The data obtained for testing of samples in the Residue Plan for the years 1998 to 2008 show the following:

- (a) *no samples have been found to be non-compliant for Group A1 and A3 to A5 substances, with the exception of one bovine sample, of 532 tested, found to be non-compliant for a Group A3 substance (nortestosterone) in the Residue Plan for 1998;*
- (b) *In 2008, eight bovine samples, one ovine sample, and three porcine samples, were non-compliant for Group A2 substances (thiourcil);*
- (c) *in the Residue Plan for 1998, one bovine sample, of 146 tested, and one ovine sample, of 25 tested, were non-compliant for Group A6 substances (furazolidone);*
- (d) *in the Residue Plan for 1999, one bovine sample, of 139 tested, was non-compliant for Group A6 substances (furazolidone);*
- (e) *in the Residue Plan for 2005, six bovine samples from two farms were non-compliant for Group A6 substances (furazolidone) – the levels determined were below the action limit for this drug;*
- (f) *in the Residue Plan for 2008, 10 bovine samples from one farm were non-compliant for Group A6 substances (furazolidone); one bovine and ovine samples were non-compliant for nitrofurazone;*
- (g) *for the group B substances (veterinary drugs and contaminants), the major occurrence of non-compliant samples was for Group B1 (antimicrobials) - Figure 2.1 shows a breakdown of the percentage non-compliant samples determined for each of the main meat species (1998-2008) and for milk (1999-2008);*

Table 2.4 Testing performed by designated laboratories for the Residue Plan (2008)

	Substance Group	Approved Laboratory	
		Screening	Confirmatory*
A1	Stillbenes	IEC	SL
A2	Thyreostats	CMCL	CMCL
A3	Steroids	IEC, CMCL	SL
A4	Zeranol	CMCL	SL
A5	Beta-agonists	CMCL	CMCL
A6	Chloramphenicol Sedatives Nitrofurans Nitroimidazoles	CMCL, IEC	CMCL CMCL AFRC SL
B1	Antimicrobials	IEC, CMCL, DSL (milk)	CMCL
B2a	Anthelmintics		AFRC
B2b	Anticoccidials		AFRC
B2c	Carbamates/Pyrethroids		AFRC
B2d	Sedatives		CMCL
B2e	Non-steroidal anti-inflammatory drugs (NSAIDs)	IEC	SL
B2f	Carbadox Corticosteroids	CMCL IEC	CMCL SL
B3a	Organochlorine compounds		PL
B3b	Organophosphorus compounds		PL
B3c	Chemical elements		CMCL
B3d	Mycotoxins		SL

* In most cases, the listed laboratories are the designated National Reference Laboratory for the substance or group of substances

CMCL - Central Meat Control Laboratory
IEC - Irish Equine Centre
PL - Pesticide Control Service Laboratory

DSL - Dairy Science Laboratory
AFRC - Ashtown Food Research Centre
SL - State Laboratory

- (h) *a high occurrence of non-compliant samples for Group B1 substances was determined in equine samples over the period 1998 to 2000 but this was not observed for samples taken during the subsequent seven years;*
- (i) *non-compliant samples for Groups B2a (anthelmintics) and B2c (carbamates and pyrethroids) have been found sporadically in bovine, ovine, equine and milk samples;*
- (j) *In 2008, non-compliant residues for B2a anthelmintics were detected one bovine samples; one ovine sample; one duck sample; and five milk samples;*
- (k) *prior to 2004, non-compliant samples for Group B2b (anticoccidials) were found only in 2001, when 2 and 3 samples of ovine and porcine tissue were determined to be non-compliant for ionophores, representing approximately 3% and 10% of samples tested, respectively;*

- (l) for the 2004 Residue Plan, testing for anticoccidial feed additives was extended to include nicarbazin and lasalocid - 20 samples of poultry tissue were found to be non-compliant for nicarbazin (representing 20% of samples tested) and 2 samples of eggs and 1 sample of ovine tissue were found to be non-compliant for lasalocid (representing approximately 5% and 2% of samples tested, respectively);
- (m) for the 2005, 2006, 2007 and 2008 Residue Plans, 6-7% of samples of poultry tissue were found to be non-compliant for nicarbazin;
- (n) for the 2006 Residue Plan, one egg sample, of 57 tested, was found to be non-compliant for nicarbazin;
- (o) non-compliant samples of porcine tissue for Group B2f (carbadox) were determined in 1999 and 2001 at an incidence rate of approximately 8% and 2% of samples tested, respectively;
- (p) no samples were found to be non-compliant for Group B2d (sedatives) and only one sample (in 2005) for Group B2e (non-steroidal anti-inflammatory drugs) was non-compliant during the ten years Residue Plan testing covered by this report;
- (q) for Group B3 substances (other substances and environmental contaminants), in 2004 and in 2007, a sample of wild game was found to be non-compliant for Group B3c (heavy metals), and, in 2006, one sample each of porcine tissue and of ovine tissue were found to be non-compliant for Group B3a (organochlorine compounds – lindane) and for Group B3b (organophosphorus compounds – diazinon), respectively. In 2008, 90 samples (mainly bovine and porcine) were found to be non-compliant for PCBs. An additional sample of wild game was found to be non-compliant for Group B3c (heavy metals).

Table 2.5 Summary data for the results of the Residue Plan for 1998 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Slaughter	Wild	Farm	Farm	Production
Total, Group A	1508/1	1135/1	21/0	455/0	161/1		9/0	319/0			274/0	17/0	
A1 Stilbenes	124	93	1	50	27		1	68					
A2 Thyrostats	47	23		14	7			25					
A3 Steroids	722	532/1	7	194	59			33					
A4 Zeranol	166	111	6	39	17		3	62					
A5 Beta-agonists	303	256	1	111	26		2	62					
A6 Annex IV substances	146/1	120	6	47	25/1		3	69			274	17	
Total, Group B	2/0	1623/20		302/1	502/0	23/5		387/1			536/3	30/0	
B1 Antimicrobials	1	1088/19		94/1	272	23/5		197/1			270/3	21	
B2a Anthelmintics	1	368		117	138			60			266		
B2b Anticoccidials		75		25	39			50				9	
B2c Carbamates/ Pyrethroids		48/1		26	28			15					
B2d Sedatives													
B2e NSAIDs		44		20	25			26					
B2f Other pharmacologically active substances				20				39					
B3a Organochlorine compounds													
B3b Organophosphorus compounds													
B3c Chemical elements													
B3d Mycotoxins													

Table 2.6 Summary data for the results of the Residue Plan for 1999 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Farmed	Wild	Farm	Farm	Production
Total, Group A	1198/0	1657/1	7/0	439/0	319/0		85/0	354/0			357/0	56/0	
A1 Stilbenes	104	92	1	47	31		22	69					
A2 Thyrostats	63	123		24	16			21					
A3 Steroids	577	691	1	164	102		8	36			76	1	
A4 Zeranol	112	136	3	42	36		15	69					
A5 Beta-agonists	191	476	1	78	92		20	68				1	
A6 Annex IV substances	151	139/1	1	84	42		20	91			281	54	
Total, Group B		2994/35		644/11	1100/1	44/1	5/0	477/0	20/0		700/5	127/0	
B1 Antimicrobials		2260/35		192/7	693/1	44/1		226	20		260/4	87	
B2a Anthelmintics		367		149	187			134			286/1		
B2b Anticoccidials		100		27	68			45				40	
B2c Carbamates/ Pyrethroids		43		24	38			18					
B2d Sedatives											62		
B2e NSAIDs		40		18	39			14					
B2f Other pharmacologically active substances		6		54/4	2		5	33					
B3a Organochlorine compounds		28		48	31						45		
B3b Organophosphorus compounds		49		36	12						47		
B3c Chemical elements		101		96	30			7					
B3d Mycotoxins													

Table 2.7 Summary data for the results of the Residue Plan for 2000 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Farmed	Wild	Farm	Farm	Production
Total, Group A	1831/0	2234/0	97/0	705/0	402/0	14/0	32/0	337/0	10/0		314/0	51/0	
A1 Stilbenes	91	131	17	64	35		10	55					
A2 Thyrostats	93	116	9	38	18			21	2				
A3 Steroids	690	733	18	254	146	14	3	33			65		
A4 Zeranol	151	190	18	62	66		7	51					
A5 Beta-agonists	557	888	16	158	89		5	55	1				
A6 Annex IV substances	249	176	19	129	48		7	122	7		249	51	
Total, Group B		2533/8		548/0	1074/1	22/8	4/0	496/0	89/0	15/0	569/2	130/0	13/0
B1 Antimicrobials		1635/8		119	659/1	14/8		204	31	5	242/2	87	7
B2a Anthelmintics		566		147	202	8		81	17		245		
B2b Anticoccidials		104		44	72			82	20			43	6
B2c Carbamates/ Pyrethroids		51		24	49			21	6				
B2d Sedatives		5		22	5								
B2e NSAIDs		47		24	34			14	1				
B2f Other pharmacologically active substances				73			4	32					
B3a Organochlorine compounds		37		66	26			32	14	10	58		
B3b Organophosphorus compounds		14		19	22						24		
B3c Chemical elements		74		10	5			30					
B3d Mycotoxins													

Table 2.8 Summary data for the results of the Residue Plan for 2001 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Slaughter	Wild	Farm	Farm	Production
Total, Group A	1739/0	2148/0	73/0	638/0	341/0	100/0	45/0	337/0	17/0		302/0	46/0	
A1 Stilbenes	92	113	10	69	19		10	51	2				
A2 Thyrostats	78	122	10	21	18			16	2				
A3 Steroids	615	641	17	205	85	100	7	56	2		53		
A4 Zeranol	153	196	12	65	51		5	50	2				
A5 Beta-agonists	636	846	13	117	83		8	48	5				
A6 Annex IV substances	165	230	11	161	85		15	116	4		249	46	
Total, Group B		2618/4		52431/352	987/5	194/0		441/0	72/0	36/0	733/0	145/0	14/0
B1 Antimicrobials		1727/4		52030/346	613/2	45		191	24		255	91	7
B2a Anthelmintics		520		134	166/1	100		72	10		251		
B2b Anticoccidials		92		31/3	64/2			88	10			54	
B2c Carbamates/ Pyrethroids		61		38	38			18	6				7
B2d Sedatives		16		59	10								
B2e NSAIDs		55		15	26	49		11	3				
B2f Other pharmacologically active substances				62/1									
B3a Organochlorine compounds		91		55	51			45	11		58		
B3b Organophosphorus compounds		91		55	51						58		
B3c Chemical elements		56		9	18			18	7	36			
B3d Mycotoxins											103		

Table 2.9 Summary data for the results of the Residue Plan for 2002 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Slaughter	Wild	Farm	Farm	Production
Total, Group A	2191/0	2240/0	167/0	573/0	333/0	173/0	87/0	336/0	9/0		277/0	49/0	
A1 Stilbenes	112	103	30	55	13		20	48	1				
A2 Thyrostats	101	121	3	33	26			15	1				
A3 Steroids	926	733	24	163	97	173	16	60	1		64		
A4 Zeranol	171	234	21	58	55		15	52				1	
A5 Beta-agonists	693	843	41	115	70		18	48	3				
A6 Annex IV substances	188	206	48	149	72		18	113	3		213	48	
Total, Group B		2775/7		57236/280	1066/0	362/1		2865/5	48/0	44/0	619/1	138/0	29/0
B1 Antimicrobials		1718/6		56757/280	678	92		2612/5	16	7	223/1	95	8
B2a Anthelmintics		559/1		124	164	181/1		72	7		251		
B2b Anticoccidials		119		37	61			82	4			29	
B2c Carbamates/ Pyrethroids		67		50	36			23	2				7
B2d Sedatives		22		58	15								
B2e NSAIDs		48		22	22	84		9	3				
B2f Other pharmacologically active substances		3		84	3			1					
B3a Organochlorine compounds		110		34	45			39	2		58	14	11
B3b Organophosphorus compounds		16		20	6						1		3
B3c Chemical elements		81		37	28	5		16	14	37			
B3d Mycotoxins		32		13	8			11			86		

Table 2.10 Summary data for the results of the Residue Plan for 2003 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Farmed	Wild	Farm	Farm	Production
Total, Group A	1929/0	2076/0	145/0	610/0	433/0	39/0	80/0	438/0	1/0		236/0	54/0	8/0
A1 Stilbenes	100	95	21	56	18		13	54					
A2 Thyrostats	96	139	21	39	44		4	20					
A3 Steroids	809	687	21	187	142	39	12	63					
A4 Zeranol	156	195	21	54	62		13	58					
A5 Beta-agonists	616	785	21	114	83		18	54					
A6 Annex IV substances	152	175	40	160	84		20	189	1		236	54	8
Total, Group B	1/0	2824/12		48653/186	1206/0	57/0		498/0	19/0	47/0	658/0	174/0	15/0
B1 Antimicrobials		1838/12		48200/186	730	6		218	7		235	102	8
B2a Anthelmintics		513		129	175	45		75	1		223		
B2b Anticoccidials		87		32	66			97	1			62	
B2c Carbamates/Pyrethroids		62		37	49			28					7
B2d Sedatives											3		
B2e NSAIDs		49		27	31	6		10	5				
B2f Other pharmacologically active substances				103									
B3a Organochlorine compounds		94		46	43			27			53	10	11
B3b Organophosphorus compounds		31		23	24						53		3
B3c Chemical elements		126		45	75			31	5	47	3		
B3d Mycotoxins	1	24		11	13			12			88		

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Table 2.11 Summary data for the results of the Residue Plan for 2004 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Farmed	Wild	Farm	Farm	Production
Total, Group A	2234/0	2348/0	135/0	739/0	487/0	57/0	92/0	392/0	8/0		232/0	102/0	11/0
A1 Stilbenes	124	141	24	66	18	4	14	51					
A2 Thyrostats	117	121	22	30	27	2	16		3				
A3 Steroids	866	837	24	218	130	12	14	33					
A4 Zeranol	181	198	17	56	60	10	15	54	1				
A5 Beta-agonists	652	694	26	121	101	2	16	43	2				
A6 Annex IV substances	294	357	22	248	151	27	17	211	2		232	102	11
Total, Group B	81/0	3248/16	99/0	31984/91	1373/4	104/0		2577/21	75/0	100/1	783/2	181/2	30/0
B1 Antimicrobials		2056/16	1	31476/91	839/3	34		2254/2	34		225/2	131	10
B2a Anthelmintics		559		128	231	24		88	5		223		
B2b Anticoccidials		105		22	63/1			101/19	5			41/2	
B2c Carbamates/Pyrethroids		75		50	53			35	4				10
B2d Sedatives		31		57	12	10					34		
B2e NSAIDs	81	44	98	23	20	21		12	2				
B2f Other pharmacologically active substances		75		119	23	3							
B3a Organochlorine compounds		75		32	35			29	5		67	9	5
B3b Organophosphorus compounds		57		25	28						67		5
B3c Chemical elements		138		34	57	12		36	20	100/1	100		
B3d Mycotoxins		33		18	12			22			67		

Table 2.12 Summary data for the results of the Residue Plan for 2005 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Caprine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Farmed Slaughter	Wild Slaughter	Farm	Farm	Production
Total, Group A	2669/0	2714/6	200/0	751/0	476/0	67/0		546/0	10/0		249/0	95/0	20/0
A1 Stilbenes	171	120	25	60	22	11		73	1				
A2 Thyrostats	127	127	26	35	20	10		42	1				
A3 Steroids	1046	1037	50	237	115	11		45	1				
A4 Zeranol	251	218	31	55	56	3		78	1				
A5 Beta-agonists	700	716	31	98	90	8		30	3				
A6 Annex IV substances	374	496/6	37	266	173	24		278	3		249	95	20
Total, Group B	141/1	6085/35	83/0	25531/26	1540/6	86/0		2570/16	72/0	96/0	830/2	183/0	82/0
B1 Antimicrobials		4780/35		24924/26	952/6	30		2119	16		254/2	121	20
B2a Anthelmintics		597		147	254	21		93	6		247		
B2b Anticoccidials		113		32	68			225/16	6			52	
B2c Carbamates/Pyrethroids		97		40	51			43	5				20
B2d Sedatives		36		65	15	7							
B2e NSAIDs	93/1	64	83	27	38	18		19	1				
B2f Other pharmacologically active substances	48	105		175	48	5							
B3a Organochlorine compounds		62		37	36			25	9		60	10	10
B3b Organophosphorus compounds		59		33	35						60		21
B3c Chemical elements		141		38	34	5		28	29	96	140		
B3d Mycotoxins		31		13	9			18			69		11

Table 2.13 Summary data for the results of the Residue Plan for 2006 (No. of samples tested/No. of samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Farmed Slaughter	Wild Slaughter	Farm	Farm	Production
Total, Group A	2093/0	2502/0	38/0	704/0	533/0	75/0	97/0	475/0	17/0		269/0	88/0	26/0
A1 Stilbenes	120	120	4	53	21	7	15	56	2				
A2 Thyrostats	119	131	6	36	22	5	14	20	2		15		
A3 Steroids	826	917	11	208	133	10	14	31	2		16		
A4 Zeranol	150	194	5	46	73	3	11	57	2				
A5 Beta-agonists	545	617	6	99	112	28	19	57	3				
A6 Annex IV substances	333	523	6	262	172	22	24	254	6		238	88	26
Total, Group B	85/0	6663/18	15/0	9685/12	1674/4	209/0		804/14	71/0	100/0	925/0	190/1	59/0
B1 Antimicrobials		5217/18		9024/11	1012/2	42		332	17		246	122	13
B2a Anthelmintics		601		155	279/1	38		93	12		278		
B2b Anticoccidials		122		34	79	9		221/14	12			57/1	
B2c Carbamates/Pyrethroids		99		42	67	19		41	6				26
B2d Sedatives		36		65	15	16							
B2e NSAIDs	85	85	15	41	37	59		20	2		78		
B2f Other pharmacologically active substances	48	129		186	50	9					95		
B3a Organochlorine compounds		57		41/1	37	4		24	6		60	11	4
B3b Organophosphorus compounds		59		33	39/1	4					60		6
B3c Chemical elements		141		29	43	9		46	16	100	55		
B3d Mycotoxins		32		20	16			27			53		10

Table 2.14 Summary data for the results of the Residue Plan for 2007 (No. of samples tested/No. of samples non-compliant)

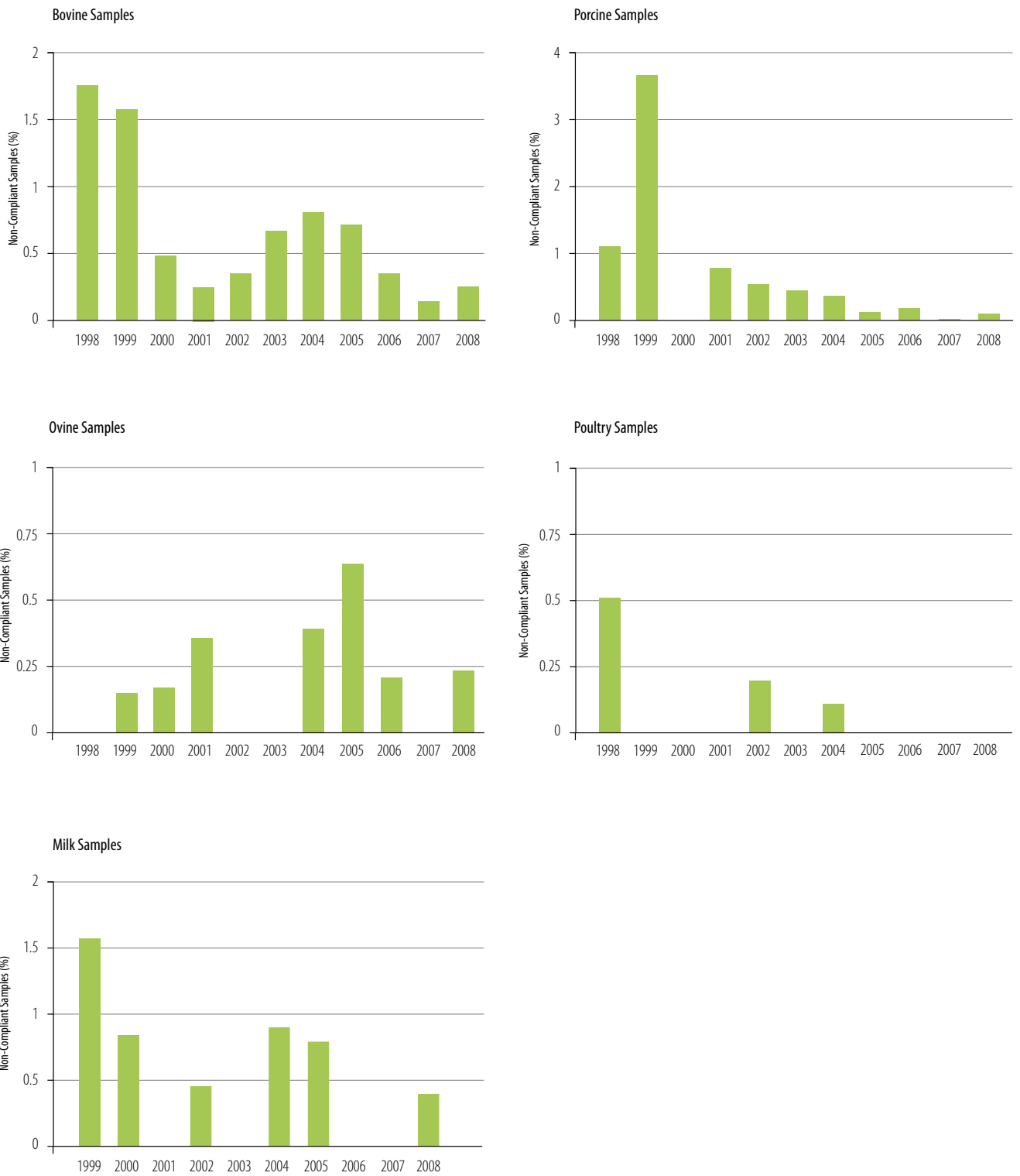
Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Farmed Slaughter	Wild Slaughter	Farm	Farm	Production
Total, Group A	2278/0	2393/0	55/0	775/0	542/0	68/0	105/0	470/0	20/0		298/0	116/0	20/0
A1 Stilbenes	122	121	7	62	22	6	19	55	2				
A2 Thyrostats	124	144	9	43	22	6	13	25	2				
A3 Steroids	949	809	16	239	134	12	15	31	2		58		
A4 Zeranol	154	159	7	50	69	3	13	56	2				
A5 Beta-agonists	577	629	8	116	119	20	18	45	6				
A6 Annex IV substances	352	531	8	265	176	21	27	258	6		240	116	20
Total, Group B	114/0	6607/6	26/0	11818/1	1688/0	160/0		878/14	115/0	94/1	836/2	182/0	96/0
B1 Antimicrobials		5267/6		11125/1	1000	39		382	25		214	118	28
B2a Anthelmintics		605		169	287	20		100	12		234/2		
B2b Anticoccidials		122		43	78	5		227/14	12			53	
B2c Carbamates/Pyrethroids		113		54	62	15		41	6				20
B2d Sedatives		35		60	15	11							
B2e NSAIDs	114	75	26	37	40	39		21	4		77		
B2f Other pharmacologically active substances		104		199	46	10					83		
B3a Organochlorine compounds		55		37	47	3		23	12		57	11	9
B3b Organophosphorus compounds		57		37	38	4					57		19
B3c Chemical elements		138		41	60	10		59	44	94/1	56		10
B3d Mycotoxins		36		16	15	4		25			58		10

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Table 2.15 Summary data for the results of the Residue Plan for 2008 (No. samples tested/No. samples non-compliant)

Sampling Point:	Bovine		Porcine		Ovine	Equine	Poultry		Cervine		Milk	Eggs	Honey
	Farm	Slaughter	Farm	Slaughter	Slaughter	Slaughter	Farm	Slaughter	Farmed Slaughter	Wild Slaughter	Farm	Farm	Production
Total, Group A	2,157/17	2,266/2	52	629/3	490/2	68	120	475	19		365	108	20
A1 Stilbenes	116	117	7	54	21	5	22	52	2				
A2 Thyrostats	116/6	133/2	9	33/3	28/1	5	16	20	2				
A3 Steroids	821	767	17	192	138	10	14	29	1		94		
A4 Zeranol	147	161	6	39	73	3	20	52	2				
A5 Beta-agonists	529	608	5	98	113	20	19	49	6				
A6 Annex IV substances	428/11	521	8	243	189/1	21	33	239	6		271	108	20
Total, Group B	102/0	7,353/63	25/0	12,625/47	1,596/3	182/0		785/16	92/0	102/1	878/6	189/5	100/0
B1 Antimicrobials		5,867/13		11,926/8	896/2	43		355	10		269/1	121	30
B2a Anthelmintics		599/1		142	257/1	28		88/1	13		278/5		
B2b Anticoccidials		120		29	75	5		201/13	13			55/5	
B2c Carbamates/Pyrethroids		103		37	56	15		35	11				20
B2d Sedatives		41		64	28	15							
B2e NSAIDs	102	82	25	29	42	40		16	4		89		
B2f Other pharmacologically active substances		98		176	48	10					78		
B3a Organochlorine compounds		149/49		98/39	46	4		24/2	12		72	13	10
B3b Organophosphorus compounds		60		32	40	4					46		20
B3c Chemical elements		158		41	68	8		56	29	102/1	63		10
B3d Mycotoxins		37		14	16	4		23			72		10

Figure 2.1 Non-compliant samples for substance group B1 (antimicrobials) for each year of testing for the Residue Plan



Monitoring Programmes for Fish & Shellfish

CHAPTER THREE

3.1 Aquaculture (Farmed Finfish)

3.1.1 Introduction

On an annual basis, farmed finfish are monitored for the presence of residues of prohibited substances, veterinary drugs, pesticides, heavy metals, dyes and other contaminants. As for foods of animal origin (Chapter 2), a Residue Testing Plan is developed each year in accordance with Council Directive 96/23/EC. The Department of Agriculture, Fisheries and Food (formerly the Department of Communications, Marine and Natural Resources), under service contract to the FSAI, is responsible for the national residues control programme for aquaculture. On their behalf, the Sea Fisheries protection Authority (SFPA) with support from the Marine Institute (MI) are responsible for the implementation of this directive with respect to finfish. The annual residues monitoring plan for farmed finfish is agreed between the Marine Institute, DAFF and FSAI.

Council Directive 96/23/EC specifies the substances and groups of residues to be monitored in aquaculture and the same provisions as apply to foods of animal origin, in respect of the targeted sampling strategy to be used, the sampling levels and frequency to be applied, and the official control measures and actions to be taken in the case of non-compliant results or other infringements occurring, also apply to farmed finfish. Table 3.1 lists the substances and groups of residues that are required to be monitored in fish, together with the minimum number of fish from which samples must be taken (2008 figures). The minimum number of samples is expressed as 1% of production (tonnes) in the previous year and one-third of the

samples are tested for Group A substances and two-thirds of the samples are tested for Group B substances. For example, production in 2008 was 15384 tonnes, requiring a minimum number of samples of 154 (Group A substances - 52 samples, Group B substances - 103 samples). (Note: The Marine Institute also undertakes a monitoring programme for contaminants in fish and shellfish. These studies are described in section 3.2 of this chapter).

3.1.2 Sampling and Analysis

Authorised officers (under the Animal Remedies Act, 1993) collect samples of each species of farmed finfish that is produced in greater quantity than 100 tonnes in a year; this specification currently covers salmon, freshwater trout and sea reared trout. Other species that may be included in the future, depending on production levels, are arctic char, eel and turbot. Samples are collected during



Table 3.1 Listing of substances to be included in the Residue Plan for Farmed Finfish

Substance Group		Minimum No. of Samples/Tests (2008)
GROUP A - Substances having anabolic effect and unauthorized substances		
A3	Steroids, including both natural hormones and synthetic steroids	144
A6	Compounds included in Annex IV to Council Regulation (EEC) No. 2377/90 of 26 June 1990 (e.g. chloramphenicol, nitrofurans, etc.)	62
GROUP B - Veterinary drugs⁽¹⁾ and contaminants		
B1	Antibacterial substances, including sulphonamides, quinolones, tetracyclines	103
B2a	Anthelmintics	103
B2c	Pyrethroids	103
B2f	Other pharmacologically active substances (e.g. teflubenzuron, diflubenzuron)	52
B3a	Organochlorine compounds, including PCBs	21
B3c	Chemical elements (e.g. lead, cadmium, mercury,)	21
B3d	Mycotoxins	7
B3e	Dyes (e.g. malachite green)	85

⁽¹⁾ Includes unlicensed substances that could be used for veterinary purposes

Table 3.2 Testing performed by approved laboratories for the Residue Plan for Farmed Finfish (2008)

	Substance Group	Approved Laboratory	
		Screening	Confirmatory
A3	Steroids	IEC	CRL
A6	Chloramphenicol Nitrofurans	IEC	CRL AFRC
B1	Antimicrobials	MI	MI
B2a	Anthelmintics		MI
B2c	Pyrethroids	MI	LGC
B2f	Teflubenzuron, Diflubenzuron Corticosteroids	IEC	MI CRL
B3a	Organochlorine compounds and PCBs		MI
B3c	Chemical elements		MI
B3d	Mycotoxins		LGC
B3e	Dyes		MI/LGC

Laboratories:

MI - Marine Institute

CRL - Community Reference Laboratory

IEC - Irish Equine Centre

LGC - Laboratory of the Government Chemist (UK)

AFRC – Ashtown Food Research Centre



growth of the fish (on farm) and at the time of harvest and are maintained under a strict chain of custody. Archive samples are retained by the Marine Institute and are available for testing by reference laboratories in the event of a disputed result.

Analyses are undertaken at the marine institute laboratories or, for some substances, by subcontract to other specialist laboratories. These other laboratories are formally approved by the Marine Institute as part of the annual residues monitoring plan for aquaculture. Each laboratory is approved to perform specific tests, screening and/or confirmatory, for specific substances or groups of substances. The approved laboratories are required to perform residue testing at the appropriate standard, including use of accredited methods, to ensure the accuracy of test results. In addition to the approved laboratories, certain laboratories are designated as National Reference Laboratories for specific substances (as described for foods of animal origin in Chapter 2 of this report). The Marine Institute is the National Reference Laboratory for aquaculture only for the following substances: B2a substance- emamectin, B2f substances- teflubenzuron and diflubenzuron, and for the B3e substances, malachite green and leucomalachite green.

The samples are sent to the testing laboratory designated to undertake official testing for the substances for which the samples were taken. Table 3.2 gives a general summary of the categories of testing undertaken by the laboratories approved for the Residue Plan for Farmed Finfish; this summary reflects the situation in 2008 but may change. Analyses may be by screening tests - relatively simple, rapid techniques to clear compliant samples and to identify possible non-compliant samples, or by confirmatory tests - definitive techniques that identify the residue present and usually measure the concentration.

Screening tests include immunoassays (Group A substances), inhibitory substance testing (Group B1 substances) and chromatographic techniques such as high performance liquid chromatography (HPLC). In the case of Group A substances, the confirmatory tests are based on mass spectrometry, GC-MS or LC-MS/MS. In the case of Group B substances, the confirmatory tests are chromatographic techniques including HPLC, GC-ECD, GC-MS and LC-MS/MS, except for Group B3(c) for which testing is performed by atomic absorption spectrophotometry. For many Group B2 and Group B3 substances, the same techniques are used for screening and confirmatory testing. The Marine Institute and approved subcontract laboratories apply quality control programmes to their analytical testing to ensure the accuracy of the results obtained, use validated methods, according to EC guidelines, and participate in proficiency schemes and inter-laboratory studies. The approved laboratories are expected to have their tests accredited to the ISO 17025 standard.

3.1.3 Results

Summary data for the results of the Residue Plan for Farmed Finfish for the years 1999 to 2008 are provided in Table 3.3. In considering the results of monitoring for each year it is important to be aware that the range of substances tested for within a group may have changed, that the specificity and sensitivity of techniques used may have changed, and that other factors may influence the comparability of results from year to year.

In farmed finfish no non-compliant samples have been determined over the period 1999 to 2008 containing Group A substances, i.e. prohibited substances. In the years 1999, 2000 and 2005, samples have been found to be non-compliant for Group B2a (Anthelmintics), representing misuse of unapproved ivermectin (1999, 2000) and of the authorized sea-lice treatment emamectin (2005). The sampling in 2003 showed a number of samples to be non-compliant for Group B1 (Antimicrobials); the non-compliant samples for antimicrobials related to one batch of samples from one farm and indicate potential misuse of licensed antimicrobials in treatment of farmed finfish, related to incorrect dosage and/or non-observance of specified withdrawal periods. In the years 2000 and 2002-2004, samples have been found to be non-compliant for Group B3e (Dyes); the residues found were of (leuco)malachite green, an antifungal and ectoparasite drug that is not approved for use on farmed finfish. The increased incidence of non-compliant samples found in 2003, 14.5% of samples tested, may reflect the increased sampling in that year compared to previous years. The incidence of non-compliant samples for Group B3e substances in 2004 was 5.6% of

samples tested and no samples were found to be non-compliant in the period 2005 to 2008. Use of malachite green in farmed fish has been identified as a problem in the UK monitoring programme, also, with a reported incidence of non-compliant samples of 17, 11, 4 and 2% in 2001, 2002, 2003 and 2004, respectively, and ~1% each year in 2005 to 2007, although with no detectable residues in 2008 (Veterinary Residues Committee 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008).

Veterinary Residues Committee. 2001. Annual Report on Surveillance for Veterinary Residues in Food in the UK.

Veterinary Residues Committee. 2002. Annual Report on Surveillance for Veterinary Residues in Food in the UK.

Veterinary Residues Committee. 2003. Annual Report on Surveillance for Veterinary Residues in Food in the UK.

Veterinary Residues Committee. 2004. Annual Report on Surveillance for Veterinary Residues in Food in the UK.



Table 3.3 Summary data for results of the Residue Plan for Farmed Finfish (Targeted Sampling) for 1999 to 2008 (No. of samples tested/No. of samples non-compliant)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total, Group A	236/0	240/0	272/0	257/0	240/0	330/0	162/0	155/0	108/0	104/0
A1 Stilbenes	59	60	68	14						
A3 Steroids	59	60	68	81	80	130	54	53	54	52
A5 Beta-agonists	59	60	68	81	80	91	54	51		
A6 Annex IV substances	59	60	68	81	80	109	54	51	54	52
Total, Group B	532/1	582/9	794/0	789/1	782/13	640/5	569/2	550/0	547/0	548/0
B1 Antimicrobials	106	118	135	134	163/4	124	105	104	103	103
B2a Anthelmintics	106/1	110/4	126	130	162	130	104/2	104	103	103
B2c Pyrethroids	106	110	129	126	163	121	104	104	103	103
B2f Other pharmacologically active substances			127	127	162	124	105	104	103	103
B3a Organochlorine compounds	102	118	133	130	34	25	21	21	21	21
B3c Chemical elements	106	118	135	134	36	26	21	21	21	21
B3d Mycotoxins							7	7	7	7
B3e Dyes	6	8/5	9	8/1	62/9	90/5	102	85	86	87



Veterinary Residues Committee. 2005. Annual Report on Surveillance for Veterinary Residues in Food in the UK.

Veterinary Residues Committee. 2006. Annual Report on Surveillance for Veterinary Residues in Food in the UK.

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Veterinary Residues Committee. 2008. Annual Report on Surveillance for Veterinary Residues in Food in the UK.

3.2 Trace Metals and Chlorinated Hydrocarbons in Fish and Shellfish, 1997 - 2007

3.2.1 Introduction

The Marine Institute monitors the levels of priority hazardous substances in a range of commercial fish species landed at Irish ports and also in shellfish from selected sites around the Irish coast on an annual basis. This monitoring programme is undertaken to comply with the requirements of EU legislation and to contribute to the Joint Assessment and Monitoring Programme required by the 1994 OSPAR convention. The relevant EU legislation includes EU Council Directive 2006/113/C (codified version) on the quality required of shellfish growing areas and Commission Regulation (EC) No 629/2008 amending Regulation (EC) No 1881/2006 setting maximum levels for mercury, cadmium and lead in fish and shellfish. Overall, the monitoring programme is designed to ensure the quality of marine foodstuffs for human consumption.

3.2.2 Methodology

Samples

For finfish, samples (comprising 10 individual fish of each species) were collected at the major fishing ports of Castletownbere, Dunmore East, Howth, Killybegs and Rossaveal. For shellfish, samples of mussels (50 individuals) and oysters (25 individuals) were collected from approximately 20 of the major shellfish

growing areas. Following measurement of size and calculation of weight of edible tissue, pooled samples for each species were analysed for mercury, trace metals and chlorinated hydrocarbons.

Analysis

Following digestion of samples with nitric acid in a microwave oven, mercury was determined by Cold Vapour Atomic Fluorescence Spectroscopy. The trace metals cadmium, chromium, copper, lead, nickel, silver and zinc were analysed in samples by digestion with nitric acid/hydrogen peroxide in a microwave oven. Cadmium, chromium, copper, lead, nickel and silver contents were measured using Graphite Furnace Atomic Absorption Spectrometry and zinc content was measured using Flame Atomic Absorption Spectroscopy.

The chlorinated hydrocarbons, PCBs and organochlorine pesticides, were analysed by extracting the lipid from the samples, removing the lipid from the sample extracts by alumina column chromatography and separating PCBs from organochlorine pesticides using silica column chromatography. Chlorinated hydrocarbons content was determined by capillary column gas chromatography with electron capture detection, using two columns of different polarity for confirmation. A programme of quality control, including use of reference materials and ongoing participation in the QUASIMEME proficiency testing scheme, ensured the quality of the results obtained.

Reports

The results of each year's monitoring programme are published as reports by the Marine Institute for finfish (Tyrrell et al. 2003a, Tyrrell et al. 2003b, Tyrrell et al. 2004, Tyrrell et al. 2005) and for shellfish (McGovern et al. 2001, Glynn et al. 2003a, Glynn et al. 2003b, Glynn et al. 2004, Boyle et al. 2006); these reports may be consulted for details on individual samples. The results are made available to agencies such as the Food Safety Authority of Ireland and the European Commission. The results are also submitted to the International Council of the Seas (ICES) databank and are used by OSPAR to assess the quality of the North East Atlantic

region and to take action needed for marine protection.

3.2.3 Results

Finfish

Summary tables of results are given for the period 1997 to 2006 for mercury and trace metals (Table 3.4) and for the period 2000 to 2002 for chlorinated hydrocarbons (Table 3.5). Total mercury and trace metal concentrations in finfish from the selected Irish ports were generally low. With the exception of one sample taken in 2003 and two samples taken in 2005, all finfish samples tested for mercury, cadmium and lead were within the limits of 0.5 (1.0 mg/kg in selected species), 0.05 (0.3 mg/kg in selected species) and 0.3 mg/kg wet weight, respectively, as set by European Commission Regulation 1881/2006 (amended by Regulation 629/2008). The exceptional samples, which were dogfish (a shark species), contained mercury at 0.59 to 0.73 mg/kg wet weight; these samples were within the higher limit acceptable for shark species and it is most likely that the fish from which these samples were taken were destined for whelk bait and as

such there are no human health implications. In the absence of EU or national limits for other contaminants in fish, results were compared with the strictest standards and guidance values applied by contracting countries to the OSPAR convention. The results for copper and zinc were within the strictest guidance values applied by OSPAR countries. Chlorinated hydrocarbon concentrations in finfish from the selected Irish ports were low, with results for individual substances being well within the strictest standards and guidance values applied by OSPAR countries.

Shellfish

Summary tables of results are given for the period 1997 to 2006 for mercury and trace metals (Table 3.6) and for the period 1997 to 2002 for chlorinated hydrocarbons (Table 3.7). Total mercury and trace metal concentrations in shellfish from the selected shellfish-growing areas were low. All shellfish samples tested for mercury, cadmium and lead were within the limits of 0.5 mg/kg, 1.0 mg/kg and 1.5 mg/kg wet weight, respectively, as set by European Commission Regulation 1881/2006 (amended

Table 3.4 Summary results of monitoring of finfish for mercury and trace metals (mg/kg wet weight) from selected Irish ports, 1997-2006

Element	Limit ^(a)	1997			1998			1999					
		No. Samples	No. Species	Range	No. Samples	No. Species	Range	No. Samples	No. Species	Range			
Mercury	0.5 (-1.0) ^(b)	13	7	0.03 - 0.18	16	10	<0.03 - 0.19	35	18	<0.03 - 0.29			
Cadmium	0.05 (-0.3) ^(b)	12	7	ND - 0.014				15	8	ND - <0.011			
Chromium		12	7	ND ^(c)				15	8	ND			
Copper	10	12	7	ND - 3.77				15	8	ND - 0.56			
Lead	0.3	12	7	ND - <0.062				15	8	ND - <0.062			
Zinc	50	12	7	1.98 - 11.9				15	8	<1.62 - 4.03			
Element	Limit ^(a)	2000			2001			2002					
		No. Samples	No. Species	Range	No. Samples	No. Species	Range	No. Samples	No. Species	Range			
Mercury	0.5 (-1.0) ^(b)	48	17	0.03 - 0.33	44	20	<0.03 - 0.42	38	20	<0.03 - 0.46			
Cadmium	0.05 (-0.3) ^(b)	17	8	ND - 0.012	16	12	ND - 0.04	16	12	ND			
Chromium		17	8	ND	16	12	ND - <0.19	16	12	ND - <0.19			
Copper	10	17	8	ND - 0.61	16	12	ND - 2.56	16	12	ND - 0.91			
Lead	0.3	17	8	ND - <0.062	16	12	ND - <0.06	16	12	ND - <0.06			
Zinc	50	17	8	1.95 - 3.84	16	12	<1.61 - 12.0	16	12	1.71 - 5.17			
Element	Limit ^(a)	2003			2004			2005			2006		
		No. Samples	No. Species	Range	No. Samples	No. Species	Range	No. Samples	No. Species	Range	No. Samples	No. Species	Range
Mercury	0.5 (-1.0) ^(b)	45	22	<0.03 - 0.60	33	19	<0.03 - 0.43	36	16	0.04 - 0.73	25	17	0.03 - 0.39
Cadmium	0.05 (-0.3) ^(b)	20	15	ND - 0.07	19	14	ND	20	13	ND - <0.005	20	15	ND - <0.005
Chromium		15	13	ND - 0.22	15	12	ND	15	11	ND - 0.23	12	10	<0.05 - 0.07
Copper	10	15	13	ND - 4.35	15	12	ND - 0.45	15	11	<0.20 - 0.89	12	10	<0.20 - 1.13
Lead	0.3	20	15	ND - <0.06	19	14	ND	20	13	<0.05 - 0.06	20	10	ND - <0.05
Zinc	50	15	13	2.86 - 13.3	15	12	1.72 - 6.46	15	11	1.99 - 5.40	12	10	2.23 - 3.73
Nickel		15	13	ND	15	12	ND	15	11	ND - <0.13	12	10	ND - <0.13
Silver		15	13	ND - 0.10	15	12	ND	15	11	ND	12	10	ND - 0.014

NOTES: ^(a) Limits for Mercury, Cadmium and Lead are those set by European Regulation 1881/2006 and 629/2008; limits for Copper and Zinc are the strictest guidance values applied by OSPAR countries.

^(b) Maximum levels set for Mercury and Cadmium depend on fish species concerned.

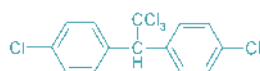
^(c) ND - not detected; current (2007) detection limits for the various elements are Mercury (0.008), Cadmium (0.002), Chromium (0.02), Copper (0.05), Lead (0.008), Zinc (1.21), Nickel (0.03), Silver (0.003).

Table 3.5 Summary results of monitoring of finfish for chlorinated hydrocarbons ($\mu\text{g}/\text{kg}$ wet weight) from selected Irish ports, 2000-2002

Substance	Reference value ^(a)	2000 (No. Samples: 15) (No. Species: 7)	2001 (No. Samples: 11) (No. Species: 11)	2002 (No. Samples: 16) (No. Species: 13)
		Range	Range	Range
PCB 28	80	ND ^(b) - 1.20	0.03 - 3.87	<0.02 - 0.18
PCB 31		0.03 - 2.07	0.09 - 15.8	<0.02 - 0.24
PCB 52	40	0.07 - 2.84	0.02 - 4.56	<0.04 - 0.65
PCB 101	80	0.07 - 2.00	0.08 - 19.8	<0.03 - 0.95
PCB 105		ND - 0.15	0.01 - 5.13	<0.04 - 0.44
PCB 118	80	0.03 - 1.18	0.03 - 8.70	<0.07 - 1.44
PCB 138	100	0.04 - 2.02	0.04 - 14.7	<0.05 - 2.39
PCB 153	100	0.09 - 3.17	0.07 - 18.7	0.04 - 3.78
PCB 156		<0.01 - 0.14	<0.01 - 0.71	<0.02 - 0.20
PCB 180	80	<0.01 - 0.68	0.01 - 5.92	<0.01 - 0.94
DDD-p,p'	500 (DDT and its transformation products)	ND - 1.19	0.01 - 13.0	
DDE-p,p'		0.02 - 4.62	0.05 - 47.7	
DDT-o,p'		ND - 0.20		
DDT-p,p'		ND - 0.98	ND - 8.09	
HCB	50	0.03 - 1.30	0.02 - 7.62	0.02 - 0.22
gamma - HCH	100	ND - 0.99	0.06 - 10.7	
alpha - HCH	50			0.01 - 0.28
trans-Nonachlor		ND - 1.36	0.01 - 8.12	<0.01 - 0.49
trans-Chlordane		ND - 0.13	ND - 7.76	<0.01 - 0.19
cis-Chlordane		ND - 0.31	<0.01 - 2.74	<0.01 - 0.28
oxy-Chlordane				<0.01 - 0.12
Aldrin	100		ND - 1.77	<0.01 - 0.07
Isodrin			ND - 2.23	
Endrin			ND - 2.27	

NOTES: (a) Reference values are the strictest guidance and standard values applied by OSPAR countries.
(b) ND - not detected.

DDT



by Regulation 629/2008). The results for copper were within the strictest standard values applied by an OSPAR country; there are no specified limits or agreed standard or guidance values for chromium or zinc in shellfish. Chlorinated hydrocarbon concentrations in shellfish from the selected shellfish-growing areas were low, with results for individual substances being well within the strictest standards and guidance values applied by OSPAR countries.

Boyle, B., Tyrrell, L., McHugh, B., Joyce, E., Costello, J., Glynn, D. and McGovern, E. 2006. *Trace Metal Concentrations in Shellfish from Irish Waters, 2003. Marine Environment and Health Series, No. 25, 2006. Marine Institute, Co. Galway.*

Glynn, D., Tyrrell, L., McHugh, B., Rowe, A., Costello, J. and McGovern, E. 2003a. *Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish Waters, 2000. Marine*

Table 3.6 Summary results of monitoring of shellfish for mercury and trace metals (mg/kg wet weight) from selected shellfish-growing areas, 1997-2006

Element	Limit ^(a)	1997		1998		1999			
		No. Samples	Range	No. Samples	Range	No. Samples	Range		
Mercury	0.5	7	0.02 - 0.05	4	0.02 - 0.03	21	0.01 - 0.05		
Cadmium	0.5 (- 1.0) ^(d)	7	0.14 - 0.44	4	0.14 - 0.27	20	0.05 - 0.57		
Chromium		7	0.08 - 0.30	4	0.12 - 0.32	20	0.15 - 0.75		
Copper ^(b)	20	4	1.47 - 1.85	3	1.31 - 1.41	12	1.34 - 2.18		
Copper ^(c)	60	3	10.9 - 27.7	1	23.9	8	4.24 - 57.9		
Lead	0.5 (- 1.5) ^(d)	7	0.09 - 0.39	4	0.05 - 0.15	20	0.03 - 0.77		
Zinc		7	13.2 - 362	4	14.4 - 270	19	14.0 - 378		
Element	Limit ^(a)	2000		2001		2002			
		No. Samples	Range	No. Samples	Range	No. Samples	Range		
Mercury	0.5	19	ND ^(e) - 0.05	23	<0.03 - 0.04	24	ND - 0.03		
Cadmium	0.5 (- 1.0) ^(d)	19	0.10 - 0.63	23	0.04 - 0.74	24	0.08 - 0.66		
Chromium		19	ND - 3.11	23	ND - 0.58	24	ND - 0.29		
Copper ^(b)	20	12	1.01 - 1.73	11	1.16 - 1.93	12	1.05 - 2.38		
Copper ^(c)	60	7	3.87 - 31.9	12	3.48 - 27.0	12	3.75 - 46.3		
Lead	0.5 (- 1.5) ^(d)	19	<0.06 - 0.54	23	<0.06 - 0.69	24	<0.06 - 0.34		
Zinc		19	10.7 - 487	23	15.1 - 680	24	10.9 - 532		
Nickel						24	ND - 0.39		
Silver						24	ND - 1.49		
Element	Limit ^(a)	2003		2004		2005		2006	
		No. Samples	Range	No. Samples	Range	No. Samples	Range	No. Samples	Range
Mercury	0.5	30	<0.03 - 0.04	30	ND - 0.04	39	<0.02 - 0.04	38	<0.02 - 0.04
Cadmium	0.5 (- 1.0) ^(d)	30	0.04 - 0.97	30	0.07 - 0.93	39	0.04 - 0.95	38	0.07 - 0.78
Chromium		30	ND - 1.12	30	ND - 0.37	39	<0.05 - 0.66	38	0.08 - 2.32
Copper ^(b)	20	17	1.04 - 2.93	18	1.02 - 1.81	24	0.96 - 1.97	24	1.31 - 2.26
Copper ^(c)	60	13	3.83 - 37.1	12	5.25 - 27.7	15	4.13 - 24.8	14	5.20 - 24.6
Lead	0.5 (- 1.5) ^(d)	30	ND - 1.04	30	<0.06 - 0.58	39	<0.05 - 0.85	38	<0.05 - 0.79
Zinc		30	12.6 - 403	30	11.5 - 367	39	9.7 - 445	38	8.9 - 488
Nickel		30	ND - 0.58	30	ND - 0.47	39	<0.13 - 0.33	38	<0.13 - 0.72
Silver		30	ND - 2.63	30	ND - 2.38	39	<0.013 - 3.36	38	<0.13 - 1.63

NOTES: (a) Limits for Mercury, Cadmium and Lead are those set by European Regulation 1881/2006 and 629/2008; the limit for Copper is the strictest standard value applied by an OSPAR country.
 (b) Copper content in mussels.
 (c) Copper content in oysters.
 (d) Maximum levels set for Cadmium and Lead depend on the shellfish species concerned.
 (e) ND - not detected; current (2007) detection limits for the various elements are Mercury (0.008), Cadmium (0.002), Chromium (0.02), Copper (0.05), Lead (0.008), Zinc (1.21), Nickel (0.03), Silver (0.003).

Table 3.7 Summary results of monitoring of shellfish for chlorinated hydrocarbons (µg/kg wet weight) from selected shellfish-growing areas, 1997-2002

Substance	Reference value ^(a)	1997	1998	1999	2000	2001	2002
		(No. Samples: 7) Range	(No. Samples: 5) Range	(No. Samples: 10) Range	(No. Samples: 11) Range	(No. Samples: 23) Range	(No. Samples: 23) Range
PCB 28	80	0.23 - 0.49	0.14 - 0.82	0.19 - 0.60	0.11 - 0.39	0.13 - 0.29	<0.01 - 0.28
PCB 31		0.25 - 0.50	0.14 - 0.79	0.05 - 0.44	0.11 - 0.39	0.07 - 0.67	0.02 - 0.13
PCB 52	80	0.48 - 0.85	0.16 - 1.61	0.35 - 1.14	0.31 - 0.79	0.38 - 0.70	0.08 - 0.25
PCB 101	80	0.50 - 0.96	0.12 - 1.37	0.34 - 0.86	0.28 - 1.07	0.35 - 1.10	0.10 - 0.53
PCB 105		ND ^(b) - 0.22	ND - 0.12	ND - 0.16	ND - 0.12	0.05 - 0.18	0.01 - 0.13
PCB 118		0.23 - 0.70	0.10 - 1.24	0.24 - 1.20	0.05 - 0.64	0.09 - 0.63	0.04 - 0.47
PCB 138	100	0.45 - 1.35	0.12 - 1.34	0.26 - 1.48	ND - 0.61	0.11 - 1.35	0.05 - 0.62
PCB 153	100	0.74 - 2.05	0.24 - 1.90	0.39 - 2.20	0.30 - 1.53	0.22 - 1.18	0.08 - 1.04
PCB 156		ND - 0.08	ND - 0.07	ND - 0.07	ND - 0.03	<0.01 - 0.14	<0.02 - 0.05
PCB 180	80	0.10 - 0.28	<0.05 - 0.23	0.08 - 0.30	0.03 - 0.11	0.01 - 0.12	<0.01 - 0.09
DDD-p,p'	500 (DDT and its metabolites)	0.17 - 0.72	ND - 0.87	0.05 - 0.86	0.05 - 0.39	ND - 0.51	<0.01 - 0.48
DDE-p,p'		0.66 - 2.30	0.11 - 2.40	0.05 - 0.91	0.23 - 1.39	0.16 - 1.42	0.09 - 0.86
DDT-o,p'					ND - 0.04		<0.01 - 0.06
DDT-p,p'		ND - 0.17	ND - 0.54	<0.05 - 0.24	ND - 0.19	ND - 0.51	<0.03 - 0.18
HCB	50	0.15 - 0.30	ND - 0.06	0.07 - 1.74	0.03 - 0.11	0.02 - 0.08	<0.01 - 0.03
gamma-HCH	100	ND - 0.24	ND - 0.22	ND - 0.65	0.13 - 0.45	0.31 - 0.92	<0.01 - 0.15
alpha-HCH	50	ND - 0.11	ND - 0.07	0.03 - 0.15			0.01 - 0.13
trans-Nonachlor				0.03 - 0.42	ND - 0.29	0.03 - 0.35	<0.01 - 0.23
trans-Chlordane		ND	ND	ND - 0.20	ND - 0.09	<0.01 - 0.15	<0.02 - 0.06
cis-Chlordane		ND - 0.08	<0.06	ND - 0.08	ND - 0.03	0.02 - 0.16	ND - <0.02
Aldrin						ND - 0.07	
Isodrin						ND - 0.17	
Endrin						ND - 0.17	ND - <0.08
Dieldrin		0.34 - 0.83	0.42 - 0.97	0.48 - 2.31	0.05 - 0.18		0.13 - 0.91

NOTES: (a) Reference values are the strictest guidance and standard values applied by OSPAR countries.
 (b) ND - not detected.

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Tyrrell, L., Glynn, D., McHugh, B., Rowe, A., Monaghan, E., Costello, J. and McGovern, E. 2003b. Trace Metal and Chlorinated Hydrocarbon Concentrations in Various Fish Species Landed at Selected Irish Ports, 2001. Marine Environment and Health Series, No. 13, 2003. Marine Institute, Dublin.

Tyrrell, L., Twomey, M., Glynn, D., McHugh, B., Joyce, E., Costello, J. and McGovern, E. 2004. Trace Metal and Chlorinated Hydrocarbon Concentrations in Various Fish Species Landed at Selected Irish Ports, 2002. Marine Environment and Health Series, No. 18, 2004. Marine Institute, Dublin.

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Joyce, E., Costello, J. and McGovern, E. 2005. Trace Metal Concentrations in Various Fish Species Landed at Selected Irish Ports, 2003. Marine Environment and Health Series, No. 20, 2005. Marine Institute, Dublin.

Tyrrell, L., McHugh, B., Joyce, E., Costello, J., Glynn, D., and McGovern, E. 2006. Trace Metal Concentrations in Shellfish from Irish Waters, 2003. Marine Environment and Health Series, No. 25, 2006. Marine Institute, Dublin.

3.3 Marine Biotoxin Monitoring Programme in Shellfish, 2008

3.3.1 Introduction

The National Marine Biotoxin Monitoring Programme for shellfish is co-ordinated by the Marine Institute's National Marine Biotoxin Reference Laboratories based in Galway, under Service level agreements with the Sea Fisheries Protection Authority (SPPA) and the FSAI (Food Safety Authority of Ireland).

Samples of shellfish species are routinely analysed for the presence of marine biotoxins by biological and chemical methods in accordance with Commission Regulation (EC) No. 1664/2006, Regulation (EC) No. 853/2004 and Regulation (EC) No. 2074/2005.

The Marine Institute (MI) as National Reference Laboratory (NRL) for Marine Biotoxins are required as part of their NRL duties under Council Decision 93/383/EEC, of 14 June 2003 on reference laboratories for the monitoring of marine biotoxins, to coordinate the activities of the National Laboratories in respect of Biotoxin analysis under the National Biotoxin Monitoring Programme which includes the organisation of intercomparison exercises and the regular auditing of the National Laboratories, En-Force Laboratories and Charles River Laboratories – Pre-Clinical Services Ireland.

The MI also participates in a number of proficiency testing schemes and intercomparison exercises including Quasimeme, BEQUALM, with the Community Reference Laboratory and also a number of individual laboratories, organisations and institutes. All test methods for the analysis

Table 3.8 Summary results of monitoring of shellfish for marine biotoxins, 2008

Shellfish	Amnesic Shellfish Poisoning (ASP) toxins			Azaspiracid (AZP) toxins			Diarrhetic Shellfish Poisoning (DSP) toxins			Paralytic Shellfish Poisoning (PSP) toxins		
	No. Samples	No. < MRL (range, µg/g)	No. > MRL (range, µg/g)	No. Samples	No. < MRL (range, µg/g)	No. > MRL (range, µg/g)	No. Samples	No. < MRL (range, µg/g)	No. > MRL (range, µg/g)	No. Samples	No. < MRL (range, µg/g)	No. > MRL (range, µg/g)
Clam	9	9 (<LOD - <LOQ)	0	71	71 (<LOD - 0.15)	0	71	71 (<LOQ)	0	11	11 (LOQ)	0
Cockle	1	1 (<LOQ)	0	17	17 (<LOD - 0.04)	0	17	17 (<LOQ)	0	1	17 (LOQ)	0
Mussel	70	70 (<LOD - 2.5)	0	1211	969 (<LOD - 0.15)	242 (0.16 - 2.07) & >LOQ)	1211	1166 (<LOQ - 0.15)	45 (0.16 - 0.92)	76	79 (LOQ)	0
Native Oyster	0	0	0	46	46 (<LOD - 0.05)	0	46	46 (<LOD - <LOQ)	0	0	0	0
Pacific Oyster	46	46 (<LOD - <LOQ)	0	541	541 (<LOD - 0.13)	0	541	541 (<LOD - 0.04)	0	46	46 (LOQ)	0
Razor Clam	8	8 (<LOD - <LOQ)	0	56	56 (<LOD - <LOQ)	0	56	56 (<LOD)	0	8	8 (LOQ)	0
Scallops	506	489 (<LOD - 18.4)	17 (23.5 - 611.8)	135	135 (<LOD - 0.07)	0	135	135 (<LOD)	0	0	0	0

LOD – limit of determination; LOQ – limit of quantification

MRL – maximum levels: for ASP toxins 20 µg/g domoic acid; for AZP toxins 0.16 µg/g azaspiracid equivalents; for DSP toxins 0.16 µg/g okadaic acid equivalents; for PSP toxins 80µg/100g Saxitoxin equivalents

of shellfish toxins via bioassay and chemical analysis remain accredited to ISO 17025 standards during 2008.

3.3.2 Methodology

Routine testing of shellfish samples (predominantly marine bi-valve mollusks) is conducted all year round for the presence of Diarrhetic shellfish poisoning (DSP) via Bioassay (EU Harmonised Method) and Liquid Chromatography-mass spectrometry (LCMS-MS), Azaspiracid Shellfish Poisoning (AZP) via Bioassay (EU Harmonised Method) and Liquid Chromatography-mass spectrometry (LCMS-MS), Paralytic Shellfish Poisoning (PSP) via Bioassay (AOAC) Amnesic Shellfish Poisoning (ASP) toxins via High Performance Liquid Chromatography with Diode Array Detector. The results of the analyses are issued on a daily basis to SFPA, FSAI, Shellfish Producers and Processors, and are published on the MI website; www.marine.ie/habs

Maximum limits for the various toxins are laid down in Commission Regulation 853/2004, as follows: paralytic shellfish poison (PSP) 800 µg/

kg (0.8 µg/g); amnesic shellfish poison (ASP) 20 mg/kg (µg/g) domoic acid; diarrhetic shellfish poisoning (DSP) 160 µg/kg (0.16 µg/g) okadaic acid equivalents; azaspiracids (AZP) 160 µg/kg (0.16 µg/g) azaspiracid equivalents.

3.3.3 Results

The results of the testing for marine biotoxins in shellfish during 2008 are shown in Table 3.8. Details for the various toxins are provided below.

Amnesic Shellfish Poisoning (ASP)

During 2008, 506 analyses for ASP were conducted on Scallop tissues (*P. maximus*), typically Gonad and adductor muscle tissues, where the levels observed on Adductor Muscle tissues (240 analyses) were all below the regulatory limit (highest level observed 7.7 µg/g⁻¹).

1 of 238 Gonad tissues analysed were observed to be above the regulatory limit > 20 µg/g⁻¹, where the highest level observed was 29.6µg/g⁻¹.

Additionally during this time period, a total

of 133 samples of *M.edulis*, *C.gigas*, *O.edulis*, *E.siliqua* & *T.philippinarium*, were analysed for the presence of Domoic & Epi-Domoic Acid (DA). All samples analysed were observed to be either < Limit of Detection (<LOD) or < Limit of Quantification (LOQ)

Diarrhetic Shellfish Poisoning (DSP)

From Mid July, DSP concentrations were observed to increase above the regulatory level in samples of *M.edulis* from Bantry and Dunmanus. These concentrations increased during August in these, where the highest concentration of 0.92 µg/g-1 Total Tissue was observed. DSP concentrations decreased during September, though concentrations did not significantly increase or decrease during October and November. Further decreases in concentrations were observed in December enabling the previously affected sites to be assigned Open status.

The predominant quantifiable DSP toxin in samples from July to August was Okadaic Acid (OA), and from late August onwards the predominant DSP toxin present was Dinophysis Toxin 2 (DTX-2).

Azaspiracids (AZP)

During 2008 AZA toxicity persisted in samples of *M.edulis* for a small period throughout January, and resulted in closures in a number of sites within Bantry & Dunmanus above the regulatory level of 0.16µg/g⁻¹ Total Tissue, as a carry over of the AZA event which began in Oct 2007. AZA concentrations were observed to decrease further to levels below the regulatory level during January resulting in Open status being assigned.

From the end of May 2007, AZA levels were observed to increase in samples of *M.edulis* from sites within Bantry and Dunmanus, and from June in sites within Kenmare to concentrations above the regulatory limit. The highest AZA concentrations above the Upper Limit of Quantification (>ULQ =>1µg/g⁻¹ Total Tissue) were observed in these sites during July – September.

AZA concentrations were also observed above the regulatory level in samples of *M.edulis* from Galway Bay, Killary Harbour, Drumcliff and Ballysadare during July and August, and also in Bruckless in August and September.

From October onwards, AZA concentrations were observed to decrease nationally, resulting in previously affected sites in the West and NorthWest being assigned Open status. In the affected sites in the SouthWest, concentrations were observed to decrease to levels < ULQ, however remained above the regulatory level. Further decreases were observed in November to below the regulatory limit, where the majority of sites within Kenmare were assigned Open status, and during December the remaining affected sites within Bantry and Dunmanus were assigned Open status.

Paralytic Shellfish Poisoning (PSP)

No samples of mussels (*M. edulis*), pacific oysters (*C. gigas*) or clams (*E. siliqua*, *T. philippinarium*) tested contained PSP toxins at or above the maximum limit of 0.8 µg/g.

Clarke, D., Duffy, C., Silke, J., Devilly, L. 2009. A Review of Shellfish Toxicity Monitoring in Ireland for 2008 in Proceedings from the 9th Irish Shellfish Safety Workshop. Marine Environment and Health Series, No. 37, 2009. Marine Institute.



Monitoring Programme for Pesticides in Food

CHAPTER FOUR

4.1 Introduction

The monitoring programme for pesticide residues in food is undertaken by the Department of Agriculture, Fisheries and Food, through its Pesticide Control Service, as a service contract on behalf of the Food Safety Authority of Ireland (FSAI). The monitoring programme is aimed at ensuring (a) that consumers are not exposed to unacceptable pesticide residue levels, (b) that authorised pesticides are correctly applied to food crops and (c) that the use of unauthorised pesticides is detected. The annual monitoring programme, agreed with the FSAI, takes into consideration (a) the annual recommendation by the European Commission concerning a co-ordinated community monitoring programme to ensure compliance with maximum levels of pesticide residues in and on cereals and certain other products of plant origin including fruit and vegetables, (b) the Annual Residue Testing Plan for Ireland drawn up in accordance with Council Directive 96/23/EC on measures to monitor certain substances and residues thereof in live animals and animal products (foods of animal origin), (c) the dietary intake patterns of Irish consumers (as identified in studies such as the Irish National Nutrition Survey 1990 and the IUNA North South Food Consumption Database 2001), and (d) the residue profile of commodities as established from the results of the monitoring programme in previous years.

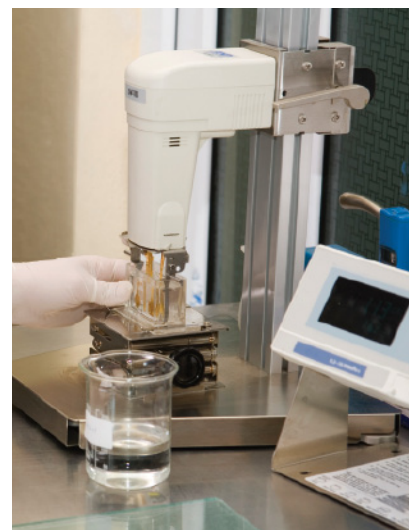
The monitoring programme covers the three food groups for which maximum residue limits (MRLs) have been established, food of plant origin (including fruit and vegetables), cereals, and food of animal origin (meat, milk and dairy products, eggs and honey). Pesticide residue levels in food are regulated through the establishment of MRLs, based on EU legislation; Commission Regulation 396/2005 controlling

pesticide residues in food is establishing MRLs for all pesticides in food. Where MRLs are exceeded, officers of the Pesticide Control Service can remove the produce concerned from the market and destroy it, at the owner's expense. The Minister for Agriculture, Fisheries and Food may also take prosecutions. Where warranted, a "Rapid Alert", as provided for under EC Regulation No. 178/2002, can be issued by the FSAI. A Rapid Alert is issued when residues detected in food are considered to be potentially harmful to the consumer.

The monitoring programme is the primary means of ensuring that authorised pesticides are used in accordance with Good Agricultural Practice and that abuses in the use of pesticides are eliminated, such as use of excessive dose rates, failure to respect the minimum periods specified between last application and harvest and use for purposes for which they are not authorised. When used in accordance with Good Agricultural Practice, unacceptable levels of pesticide residues should not occur in food. The marketing and use of certain pesticides are prohibited by the European Communities (Prohibition of Certain Active Substances in Plant Protection Products) Regulations, 1981 to 1990 because of risks to human health or the environment associated with their use. The monitoring programme serves as an indicator of the level of compliance with these provisions. The results of each annual monitoring programme are reported by the Department of Agriculture, Fisheries and Food to the FSAI and to the European Commission.

4.2 Sampling and Analysis

The monitoring programme for fruit and vegetables covers both domestic and imported produce with sampling being undertaken by officers of the Pesticide Control Service,





primarily at wholesale level. Routine sampling is loaded in favour of food commodities that are of greater dietary importance and, within each commodity group, samples are taken at random. As part of the violation investigation programme, fruit and vegetables of specific origin are targeted for further special attention where residues at levels in excess of MRLs have been found in routine sampling. In these cases and in cases arising from Food Alerts issued by the FSAI or following a Rapid Alert notification from the European Commission, the sampled lot is seized pending analysis of a statutory sample.

The monitoring programme for cereals covers products of both domestic and imported origin with sampling being undertaken by officers of the Pesticide Control Service, at point of assembly or storage. The main concern with respect to cereals relates to residues that arise as a result of post-harvest application of plant protection products and samples of grain, used in the milling, malting and breakfast cereal industries, are taken at random.

The monitoring programme for foods of animal origin covers those foods of domestic origin exclusively, with sampling being undertaken by members of the Dairy Science and Veterinary Inspectorates of the Department of Agriculture, Fisheries and Food. Random samples of bovine, porcine, ovine, poultry and venison fat are taken at meat plants and dairy produce is sampled at production plants or points of assembly. The fat samples are from individual animals while each dairy produce sample is representative of a particular bulk consignment. Egg samples are taken at random at egg packing plants.

The Pesticide Control Service laboratory is accredited to ISO 17025 for analysis of specified pesticide residues in foods of plant and of animal origin by gas chromatographic techniques. In general, the methods used are multi-residue, appropriate for pesticides of particular categories such as organochlorine, organophosphorus and benzimidazole pesticides. A comprehensive quality assurance programme is applied routinely in the

laboratory to verify that the analytical methods are being used correctly. In addition, the laboratory participates in external proficiency tests organised by the Food Analysis Performance Assessment Scheme (FAPAS), Central Science Laboratory, UK and by the European Commission.

The multi-residue analytical methods employed for pesticide residue testing involve homogenisation of samples, extraction with organic solvent, clean-up of the solvent extract using chromatographic techniques and residue determination by GC and HPLC, using specific detectors, and by GC-mass spectrometry. Quantitation of pesticide residues in sample extracts is by comparison with standards and, in the case of fruit and vegetables, using matrix-matched standards, to ensure accurate measurement of residue content.

4.3 Results

The results for the monitoring programme over the nine year period 1999 to 2007 are shown in Tables 4.1 and 4.2 (Fruit and Vegetables), 4.3 (Cereals) and 4.4 (Foods of Animal Origin). The detailed results of each year's monitoring programme are published as reports by the Pesticide Control Service, Department of Agriculture, Fisheries and Food (Pesticide Control Service 2000, 2001, 2002, 2003, 2004, 2005, 2006a, 2006b & 2007).

4.3.1 Fruit and Vegetables

In the case of fruit and vegetables, the number of samples analysed ranged between 226 and 909 per year, covering 43 to 77 different commodities in each year. The proportion of samples of domestic origin and of imported origin ranged between 18% to 36% and 82% to 64%, respectively, for the different years. The samples of fruit and vegetables were tested for 89 - 292 pesticides and metabolites in each year. No residues of pesticides were detected in approximately half of the samples tested (41-56%, depending on the year). Of the approximately half of samples of fruit and vegetables in which residues of pesticides were detected, 89-93% of these samples each year contained residues at levels less

than the relevant MRLs. The proportion of samples containing residues exceeding the relevant MRLs ranged from 2.9% to 5.1% of samples each year. Each year the number of pesticides detected in samples of fruit and vegetables ranged between 37 and 134 compounds. Taken over the nine years of the monitoring programme shown, some of the most common pesticides detected as residues in fruit and vegetables are iprodione, thiabendazole, benomyl group (including carbendazim), diphenylamine, captan, chlorpyrifos, malathion, cyprodinil, procymidone, tolyfluanid, prochloraz, methidathion, folpet, cypermethrin, chlorothalonil, fludioxinil, azoxystrobin, dicofol and chlorfenvinphos. Those pesticides associated with exceedances of the MRLs in samples on more than one year include thiabendazole, carbendazim, chlorpyrifos, iprodione, chlorothalonil, methamidophos, dicofol, chlorfenvinphos, acephate, vinclozolin, cypermethrin, azoxystrobin, dimethoate and procymidone. Table 4.2 provides a listing of the samples determined to contain pesticide residues exceeding MRLs for the period 1999 to 2007 of the monitoring programme. Details are provided on the commodity affected, the country of origin, the pesticide, the residue level present and the relevant MRL. The calculated dietary intake for the pesticides found in these commodities are shown, expressed in terms of intake as a percentage of the Acceptable Daily Intake (ADI) and, where available, intake as a percentage of the Acute Reference Dose (ARfD).

ADI values, expressed as mg pesticide per kg body weight per day, are a measure of the maximum level of intake over a lifetime adjudged to result in no adverse toxicological effects to the consumer, including the elderly, infants and children, and those whose systems are under stress because of illness. ADI values, therefore, are used to measure chronic exposure to pesticides. The intake of pesticide, expressed as mg/kg bodyweight/day, is calculated by multiplying the determined residue content (mg/kg) by the mean commodity intake (kg/day) - 97.5 percentile commodity intake for 1999 and 2000 - and dividing by an assumed body weight of 60 kg.

Intake as a percentage of the ADI is calculated by dividing the measured intake by the relevant ADI.

For the purposes of assessing the effects of acute exposure, the highest levels of exposure likely (i.e. the 97.5 percentile exposure) over a single day and the effects on health of such exposure must be considered. The level of acute exposure is considered in relation to the acute reference dose (ARfD) value established for individual pesticides. ARfD values, expressed as mg pesticide per kg bodyweight per day, are a measure of the maximum level of intake over a day adjudged to result in no adverse toxicological effects to the consumer, including the elderly, infants and children, and those whose systems are under stress because of illness. To-date ARfD values have been established for a limited number of pesticides. The assessment of acute exposure also takes into account the variability of residues in individual commodity units, particularly large sized (e.g. melons) or medium sized (e.g. citrus and pome fruit) units, due to the possibility that all of the pesticide residue may have been present in one unit. The intake of pesticide, expressed as mg/kg bodyweight/day, is calculated by multiplying the determined residue content (mg/kg) by the 97.5 percentile commodity intake (kg/day) and dividing by an assumed body weight of 60 kg. Intake as a percentage of the ARfD is calculated by multiplying the measured intake by the appropriate variability factor and dividing by the relevant ARfD.

4.3.2 Cereals

The number of samples analysed ranged between 13 and 92 per year, covering wheat and wheat products, oat and oat products, barley and barley products, and rice. The proportion of samples of domestic origin and of imported origin ranged between 45% to 70% and 55% to 30%, respectively, for the different years (with the exception of 2000 when all samples were of imports). The samples of cereals were tested for 89 - 292 pesticides and metabolites in each year. No residues of pesticides were detected in 71 to 100% of samples tested in each year and, of the samples in which detectable pesticide



residues were determined, in only one sample in 2003, and in five samples in 2006, was the relevant MRL exceeded (Table 4.3). Eight pesticides have been detected in samples of cereals, pirimiphos-methyl, malathion, deltamethrin, permethrin, chlorpyrifos-methyl, thiabendazole, diazinon and etrimfos. These pesticides were detected in samples of wheat grain and wheat products, oat grain and oat products, barley grain and in rice.

4.3.3 Foods of Animal Origin

The number of samples analysed ranged between 57 and 130 per year for bovine meat fat, 48 and 83 per year for ovine meat fat, 52 and 86 per year for porcine meat fat, 50 and 67 per year for dairy produce, 0 and 24 per year for venison, and 23 and 45 per year for poultry. Approximately 10 samples each of eggs and honey have been analysed during the six years 2002 to 2007. The samples of meat, venison, poultry, eggs and dairy produce were all of domestic origin. The samples of food of animal origin were tested for approximately 55 pesticides and metabolites, including 7 PCB congeners, in each year. No residues of pesticides were detected in 67 to

100% of the total number of foods of animal origin samples tested in each year and, of the samples for which detectable pesticide residues were determined, in two cases were the relevant MRLs exceeded in 2006 (Table 4.4). The pesticides detected in foods of animal origin are primarily the organochlorine pesticides, DDT, hexachlorobenzene, dicofol, lindane and dieldrin, PCB congeners and the organophosphorus pesticide, diazinon. The organochlorine pesticides and PCB congeners are associated with background levels in soil or feedingstuffs and the diazinon residues in fat may be associated with use of an ectoparasiticide treatment.

4.3.4 Organic Products

Between 2004 and 2007, 40 to 49 samples of fruit, vegetables and orange juice of stated organic origin were analysed for pesticide residues. Between three (2005) and eight (2006) samples contained measurable pesticide residues and, in one case, the level determined exceeded the appropriate MRL (Table 4.5). While the levels of pesticide residues determined were relatively low and did not pose a concern for the consumer, their



Table 4.1 Results for Residue Testing of Fruit and Vegetables, 1999-2007

Year	No. Samples Analysed	No. Commodities	No. Domestic Origin (%)	No. Imported Origin (%)	No. Pesticides Tested	Residues determined			No. Pesticides Detected
						No. ND (%)	No. < MRL (%)	No. > MRL (%)	
1999	226	54	81 (35.8%)	145 (64.2%)	92	124 (54.9%)	91 (40.2%)	11 (4.9%)	39
2000	238	43	54 (22.7%)	184 (77.3%)	89	112 (47.0%)	118 (49.6%)	8 (3.4%)	37
2001	301	60	88 (29.2%)	213 (70.8%)	89	152 (50.5%)	139 (46.2%)	10 (3.3%)	37
2002	559	72	102 (18.2%)	457 (81.8%)	89	270 (48.3%)	263 (47.0%)	26 (4.7%)	46
2003	894	76	216 (24.2%)	678 (75.8%)	89 ^(a)	502 (56.1%)	360 (40.3%)	32 (3.6%)	45
2004	853	77	237 (27.8%)	616 (72.2%)	118	408 (47.8%)	416 (48.8%)	29 (3.4%)	53
2005	821	71	186 (22.7%)	635 (77.3%)	148	362 (44.1%)	417 (50.8%)	42 (5.1%)	75
2006	909	75	168 (18.5%)	741 (81.5%)	153	438 (48.2%)	444 (48.8%)	27 (2.97%)	72
2007	907	67	177 (19.5%)	730 (80.5%)	292	372 (41.0%)	502 (55.4%)	33 (3.6%)	134

ND - not detected; < MRL - less than or equal to the relevant Maximum Residue Limit (MRL); > MRL - greater than the relevant MRL.

^(a) 89 pesticides and metabolites were determined in samples for the first 9 months of 2003; this number increased to 113 for the final 3 months of 2003

Table 4.2 Samples of Fruit and Vegetables with Residue Levels exceeding MRLs, 1999-2007

Year	Commodity	Country of origin	Pesticide detected	Residue content (mg/kg)	MRL (mg/kg)	Commodity intake		ADI (mg/kg bw/day)	Intake as % of ADI	ARFD (mg/kg bw/day)	Variability factor	Intake as % of ARFD
						Mean (kg/day)	97.5%ile (kg/day)					
1999	Clementine	Spain	Chlorothalonil	0.1	0.01		0.223	0.03	1.6			
	Peach	France	Methamidophos	0.2	0.01		0.143	0.004	12	0.004	7	83
	Grape	Spain	Chlorpyrifos	0.8	0.5		0.127	0.01	17	0.1	1	1.7
	Cranberry	USA	Chlorpyrifos	0.04	0.05		(0.003) ^(a)	0.01	< 0.1	0.1	1	< 0.1
	Pomegranate	Spain	Chlorpyrifos	0.1	0.05		(0.003)	0.01	0.1	0.1	7	< 0.1
	Parsnip	Ireland	Chlorfenvinphos	0.6	0.5		0.059	0.0005	118	0.002	1	30
	Melon	Brazil	Methamidophos	0.04	0.01		0.063	0.04	0.1	0.004	5	5.3
	Melon	Morocco	Chlorothalonil	1.9	1		0.063	0.03	6.7			
	Lettuce	Ireland	Iprodione	12.8	10		0.025	0.06	8.9			
	Parsley	France	Methamidophos	0.05	0.01		(0.003)	0.004	0.1	0.004	1	< 0.1
Accephate			0.6	0.02		(0.003)	0.03	0.1				
Vinclozolin			1.6	0.05		(0.003)	0.01	0.8				
Beans	UK	Chlorothalonil	0.3	0.05		0.071	0.03	1.2				
2000	Blueberry	Chile	Carbendazim	0.15	0.1		(0.003)	0.03	< 0.1			
	Cabbage	Ireland	Demeton-S-methyl-sulfone	0.72	0.5		0.057	0.0003	222	0.006	5	360
	Celery	Spain	Vinclozolin	0.06	0.05		0.033	0.01	0.33			
	Celery	Spain	Procymidone	0.42	0.02		0.033	0.01	2.3			
	Fennel	France	Vinclozolin	0.18	0.05		(0.003)	0.01	< 0.1			
	Fennel	France	Vinclozolin	0.24	0.05		(0.003)	0.01	< 0.1			
	Grapefruit	Cyprus	Thiabendazole	8.9	6.0		0.324	0.1	50			
	Pepper	Spain	Methamidophos	0.35	0.01		0.018	0.004	2.5	0.004	7	18
2001	Orange	Brazil	Triazophos	0.03	0.02	0.079	0.279	0.001	4.0	0.001	7	98
	Apple	France	Methamidophos	0.08	0.05	0.062	0.194	0.004	2.1	0.004	7	53
	Apple	France	Dicofol	0.1	0.02	0.062	0.194	0.002	5.2	0.15	7	1.5
	Kumquat	Israel	Methidathion	0.15	0.02	(0.003)	(0.01) ^(b)	0.001	0.75	0.01	1	0.25
	Passion Fruit	S Africa	Thiabendazole	1.6	0.05	(0.003)		0.1	< 0.1			
	Carrots	Ireland	Triazophos	0.05	0.02	0.027	0.083	0.001	2.3	0.001	7	49
	Lettuce	Ireland	Chlorothalonil	0.07	0.01	0.0064	0.026	0.03	< 0.1			
	Celery	Spain	Procymidone	0.27	0.02	0.0096	0.059	0.01	0.43			
	Celery	Spain	Cypermethrin	0.1	0.05	0.0096	0.059	0.05	< 0.1			
	Fennel	France	Procymidone	0.06	0.02	(0.003)	(0.01)	0.01	< 0.1			
Vinclozolin			0.17	0.05	(0.003)	(0.01)	0.01	< 0.1				
2002	Lettuce	Spain	Chlorothalonil	0.05	0.01	0.007	0.026	0.03	< 0.1			
	Celery	Spain	Cypermethrin	0.14	0.05	0.004	0.021	0.05	< 0.1			
	Strawberry	Morocco	Carbendazim	0.34	0.1	0.014	0.086	0.03	0.26			
	Kiwano	South Africa	Chlorothalonil	0.06	0.01	0.003	0.01	0.03	< 0.1			
	Pepper	Morocco	Endosulfan	1.9	1	0.013	0.053	0.006	6.9	0.02	7	58
	Blueberry	Chile	Carbendazim	0.13	0.1	0.003	0.01	0.03	< 0.1			
			Chlorothalonil	0.15	0.01	0.003	0.01	0.03	< 0.1			
			Iprodione	0.24	0.02	0.003	0.01	0.06	< 0.1			
	Spinach	Spain	Cypermethrin	0.6	0.5	0.0094	0.039	0.05	0.19			
	Parsley	Ireland	Chloropyrifos	0.19	0.05	0.0004	0.002	0.01	< 0.1	0.01	7	< 0.1
	Carrot	Spain	Endosulfan	0.06	0.05	0.0270	0.083	0.006	0.45	0.02	7	2.9
	Avocado	South Africa	Carbendazim	0.14	0.1	0.0123	0.032	0.03	0.1			
	Grapes	India	Accephate	0.06	0.02	0.0195	0.14	0.03	< 0.1	0.1	7	1.0
	Grapes	India	Accephate	1.35	0.02	0.0195	0.14	0.03	1.5	0.1	1	3.2
			Methamidophos	0.3	0.01	0.0195	0.14	0.004	2.4	0.004	1	18
	Passion Fruit	Kenya	Iprodione	0.16	0.02	0.0030		0.06	< 0.1			
Papaya	Brazil	Chlorothalonil	0.04	0.01	0.0030		0.03	< 0.1				
Parsnip	Israel	Endosulfan	0.19	0.05	0.0126	0.047	0.006	0.67	0.02	7	5.2	
Spinach	Spain	Chlorpyrifos	0.42	0.05	0.0094	0.039	0.01	0.66	0.1	7	1.9	

Year	Commodity	Country of origin	Pesticide detected	Residue content (mg/kg)	MRL (mg/kg)	Commodity intake		ADI (mg/kg bw/day)	Intake as % of ADI	ARfD (mg/kg bw/day)	Variability factor	Intake as % of ARfD
						Mean (kg/day)	97.5% ile (kg/day)					
2002	Peach	France	Methamidophos	0.07	0.05	0.0428	0.205	0.004	1.2	0.004	7	40
	Litchi	Thailand	Cypermethrin	0.13	0.05	0.0030	0.01	0.05	0.01			
	Strawberry	Ireland	Carbendazim	0.12	0.1	0.0140	0.086	0.03	0.10			
	Potato	Italy	Acephate	0.1	0.02	0.1429	0.597	0.03	0.83	0.1	7	7.0
	Kumquat	South Africa	Thiabendazole	0.22	0.05	0.0030	0.01	0.1	< 0.1			
	Swede	Ireland	Chlorpyrifos	0.09	0.05	0.0200	0.064	0.01	0.29	0.1	10	1.0
	Peach	Spain	Dicofol	0.06	0.02	0.0430	0.205	0.002	2.3	0.015	7	10
	Red Currant	Belgium	Phosalone	8.54	1	0.0030	0.01	0.02	2.1	0.3	1	0.5
	Grapes	Spain	Chlorpyrifos	0.84	0.5	0.0195	0.14	0.01	2.7	0.1	1	2.0
	Tamarillo	Chile	Chlorothalonil	0.03	0.01	0.0030	0.01	0.03	< 0.1			
2003	Broccoli	Spain	Carbendazim	0.14	0.1	0.0139	0.049	0.03	0.11			
	Raspberry	Spain	Carbendazim	0.30	0.1	0.0086	0.021	0.03	0.14			
	Carrots	Italy	Cypermethrin	0.13	0.05	0.027	0.083	0.05	0.12			
	Carrots	Ireland	Chorfenvinphos	0.55	0.5	0.027	0.083	0.0005	50	0.002	7	266
	Parsley	Italy	Chlorpyrifos methyl	0.08	0.05	0.0004	0.0024	0.01	< 0.1			
			Procymidone	0.14	0.02	0.0004	0.0024	0.01	< 0.1			
	Courgette	Spain	Chlorothalonil	0.11	0.01	0.009	0.039	0.01	0.17			
	Orange	Morocco	Chlorpyrifos	0.40	0.3	0.079	0.279	0.01	5.3	0.1	7	13
	Cucumber	Spain	Thiabendazole	0.79	0.05	0.008	0.03	0.1	0.11			
	Potato	Morocco	Carbendazim	0.15	0.1	0.143	0.597	0.03	1.2			
	Blueberry	Chile	Carbendazim	0.62	0.1	0.03	0.597	0.03	1.0			
	Apple	France	Dicofol	0.15	0.02	0.053	0.192	0.002	6.8			
	Apple	Brazil	Dicofol	0.25	0.02	0.053	0.192	0.002	11			
	Potato	Ireland	Tecnazene	0.34	0.05	0.172		0.02	4.9			
	Apple	Brazil	Dimethoate	0.07	0.02	0.053	0.192	0.002	3.2	0.03	7	5.2
	Red chard	France	Iprodione	0.16	0.02	0.003		0.06	< 0.1			
	Apple	Brazil	Dimethoate	0.16	0.02	0.053	0.192	0.002	8.3	0.03	7	12
	Apple	Brazil	Dimethoate	0.27	0.02	0.053	0.192	0.002	14	0.03	7	20
	Cherry	Greece	Carbendazim	0.23	0.1	0.002	0.0129	0.03	< 0.1			
	Potato	Ireland	Tecnazene	0.16	0.05	0.172	0.7	0.02	2.3			
	Apple	Brazil	Dimethoate	0.18	0.02	0.053	0.192	0.002	4.5	0.03	7	13
	Blackcurrant	Ireland	Endosulphan	0.08	0.05	0.003	0.01	0.006	< 0.1	0.02	7	0.47
	Passion fruit	Kenya	Chlorothalonil	0.31	0.01	0.003	0.01	0.03	< 0.1			
			Dimethoate	0.07	0.02	0.003	0.01	0.002	0.18	0.03	7	0.27
	Orange	South Africa	Bromopropylate	0.15	0.05	0.079	0.279	0.03	0.66			
	Carrots	Ireland	Triazophos	0.1	0.02	0.027	0.083	0.001	4.5	0.001	7	97
	Pear	Portugal	Dimethoate	0.06	0.02	0.033	0.149	0.002	1.7	0.03	7	3.5
	Lemons	Turkey	Bromopropylate	4.55	0.05	0.003	0.02	0.03	0.76			
	Grapefruit	Cuba	Bromopropylate	0.06	0.05	0.073	0.325	0.03	0.24			
	Lettuce	Ireland	Demeton-S- methyl sulfone	0.1	0.05	0.007	0.026	0.0003	3.9	0.02	7	1.5
Lettuce	Ireland	Azoxystrobin	3.7	3	0.007	0.026	0.1	0.43				
		Demeton-S- methyl sulfone	0.1	0.05	0.007	0.026	0.0003	3.9	0.02	7	1.5	
Celery	Ireland	Chlorpyrifos	0.51	0.05	0.004	0.021	0.01	0.34	0.1	7	1.3	
Celery	Ireland	Chlorpyrifos	0.43	0.05	0.004	0.021	0.01	0.29	0.1	7	1.1	
Pear	Belgium	Bromopropylate	0.3	0.05	0.033	0.149	0.03	0.55				
2004	Pineapple	Ivory Coast	Thiabendazole	0.71	0.05	0.016	0.092	0.1	1.9			
	Clementine	Spain	Thiabendazole	6.73	5.0	0.079	0.279	0.1	8.9			
	Celery	Spain	Procymidone	0.05	0.02	0.004	0.021	0.1	0			
	Grapefruit	Turkey	Chlorpyrifos	0.38	0.3	0.074	0.325	0.01	4.7	0.1	4	8.1
	Potato	Ireland	Tecnazene	0.16	0.05	0.25	0.805	0.02	3.3			

(Continued Over)

Year	Commodity	Country of origin	Pesticide detected	Residue content (mg/kg)	MRL (mg/kg)	Commodity intake		ADI (mg/kg bw/day)	Intake as % of ADI	ARfD (mg/kg bw/day)	Variability factor	Intake as % of ARfD
						Mean (kg/day)	97.5%ile (kg/day)					
2004	Avocado	Israel	Dicofol	0.14	0.02	0.012	0.032	0.002	1.4			
	Grape	Chile	Chlorpyrifos	0.51	0.5	0.02	0.14	0.01	1.7	0.1	5	6.0
	Blueberry	Chile	Carbendazim	0.28	0.1	0.003	0.01	0.03	0			
			Iprodione	0.29	0.02	0.003	0.01	0.06	0			
	Strawberry	Morocco	Carbendazim	0.99	0.1	0.013		0.03	0.7			
	Lettuce	Ireland	Azoxystrobin	11.85	3.0	0.007	0.026	0.1	1.4			
			Deltamethrin	1.47	0.5	0.007	0.026	0.01	1.7	0.05	5	6.4
	Parsnip	Ireland	Chlorpyrifos	0.07	0.05	0.012	0.045	0.01	0.1	0.1	6	0.3
	Apple	Brazil	Dicofol	0.3	0.02	0.054	0.192	0.002	13.5			
	Carrot	Ireland	Triazophos	0.12	0.02	0.027	0.083	0.001	5.4	0.001	7	112.6
	Mandarin	Spain	Thiabendazole	5.44	5.0	0.038	0.151	0.1	3.4			
	Carrot	Spain	Chlorpyrifos	0.13	0.1	0.027	0.083	0.01	0.6	0.1	7	1.2
	Celery	Spain	Vinclozolin	0.13	0.05	0.004	0.021	0.01	0.1			
	Blueberry	Spain	Chlorothalonil	0.35	0.01	0.003	0.01	0.03	0.1			
	Orange	Egypt	Dimethoate	0.15	0.02	0.151	0.626	0.002	18.9	0.03	2.5	13.2
	Celery	Ireland	Vinclozolin	0.26	0.05	0.004	0.021	0.01	0			
	Celery	Ireland	Cypermethrin	0.08	0.05	0.004	0.021	0.05	0			
	Strawberry	Ireland	Carbendazim	0.29	0.1	0.013	0.086	0.03	0.2			
	Lettuce	Ireland	Myclobutanil	0.04	0.02	0.007	0.026	0.03	0			
	Starfruit	Malaysia	Cypermethrin	0.07	0.05	0.003	0.01	0.05	0			
Passion fruit	Israel	Prochloraz	0.31	0.05	0.003	0.01	0.01	0.2	0.1	1	0	
Grapefruit	Spain	Dimethoate	0.04	0.02	0.074	0.325	0.002	2.4	0.03	5	3.6	
Lettuce	Ireland	Azoxystrobin	6.33	3.0	0.007	0.026	0.1	0.7				
Avocado	Israel	Mecarbam	0.09	0.05	0.012	0.032	0.002	0.9				
Passion fruit	Kenya	Chlorothalonil	0.15	0.01	0.003	0.01	0.03	0				
Beans+pods	Spain	Chlorothalonil	0.1	0.01	0.014	0.045	0.03	7.8				
2005	Grapefruit	Turkey	Chlorpyrifos	0.42	0.3	0.052	0.136	0.01	3.73	0.01	7	6.8
	Orange	Spain	Folpet	0.12	0.1	0.15	0.279	0.1	0.3			
	Orange	Spain	Thiabendazole	6.35	5	0.079	0.279	0.1	8.36			
	Orange	Egypt	Dimethoate	0.03	0.02	0.15	0.626	0.002	3.75	0.03	2.5	2.64
	Orange	Egypt	Dimethoate	0.03	0.02	0.079	0.279	0.002	1.98	0.03	5	2.07
	Orange	Israel	Captan	0.2	0.1	0.079	0.279	0.1	0.26	0.3	4	1.38
	Satsuma	Sth. Africa	Thiabendazole	8.0	5	0.043	0.151	0.1	5.73	0.9	7	16.0
	Satsuma	Sth. Africa	Iprodione	2.1	2	0.043	0.151	0.06	2.51			
	Apple	France	Thiabendazole	5.08	5	0.054	0.194	0.1	4.57			
	Pear	Holland	Thiabendazole	7.8	5	0.05	0.168	0.1	6.5			
	Pear	Russia	Dieldrin	0.07	0.01	0.05	0.168	0.0001	58			
	Pear	Portugal	Dicofol	0.23	0.02							
	Cherry	Australia	Procymidone	0.41	0.02	0.002	0.01	0.1	0.01			
	Nectarine	Chile	Dicofol	0.25	0.02	0.043	0.205	0.002	8.96			
	Peach	Spain	Prochloraz	0.09	0.05	0.043	0.205	0.01	0.65	0.1	4	1.30
	Peach	France	Esfenvalerate	0.13	0.02	0.042	0.205	0.02	0.5	0.02	4	9.4
	Grape,table	Sth. Africa	Omethoate	0.03	0.02							
			Dimethoate	0.21	0.02							
	Strawberry	Morocco	Cypermethrin	0.35	0.05	0.013	0.086	0.05	0.15			
	Strawberry	Israel	Carbendazim	1.57	0.1	0.013	0.086	0.03	1.13			

Year	Commodity	Country of origin	Pesticide detected	Residue content (mg/kg)	MRL (mg/kg)	Commodity intake		ADI (mg/kg bw/day)	Intake as % of ADI	ARfD (mg/kg bw/day)	Variability factor	Intake as % of ARfD	
						Mean (kg/day)	97.5%ile (kg/day)						
2005	Blackberry	Mexico	Carbendazim	0.42	0.1	0.003	0.01	0.03	0.07				
	Blueberry	Chile	Iprodione	0.05	0.02	0.008	0.01	0.05	0.01				
	Blueberry	Chile	Iprodione	0.05	0.02	0.003	0.01	0.05	0				
	Cranberry	Canada	Thiabendazole	0.91	0.05	0.003	0.01	0.1	0.05				
			Prochloraz	0.06	0.05	0.003	0.01	0.01	0.03	0.1		0	
			Diphenylamine	0.19	0.05	0.003	0.01	0.06	0.02				
			Dimethoate	0.03	0.02	0.003	0.01	0.002	0.08	0.03			0
			Chlorpyrifos	0.07	0.05	0.003	0.01	0.01	0.04	0.1			0
			Methidathion	0.23	0.02	0.003	0.01	0.001	1.15	0.01	1		0.38
	Iprodione	1.5	0.02	0.003	0.01	0.06	0.13						
	Kiwi	Italy	Iprodione	10.05	5	0.02	0.099	0.06	5.6				
	Kiwi	Chile	Iprodione	12.8	5	0.02	0.099	0.06	7.1				
	Papaya	Ivory Coast	Azoxystrobin	0.06	0.05	0.003	0.01	0.01	0.03				
	Papaya	Brazil	Chlorothalonil	0.02	0.01	0.003	0.1	0.03	0				
	Papaya	Brazil	Permethrin	0.08	0.05	0.003	0.01	0.05	0				
	Pineapple	Sth. Africa	Thiabendazole	0.24	0.05	0.022	0.091	0.1	0.1				
	Tamarillo	Colombia	Cypermethrin	0.07	0.05	0.003	0.01	0.05	0				
	Pepper	Spain	Bitertanol	0.09	0.05	0.01	0.026	0.01	0.15				
	Cucumber	Spain	Triadimenol	0.13	0.1	0.008	0.027	0.05	0.03				
	Cabbage	Ireland	Propyzamide	0.03	0.02	0.015	0.055	0.02	0.04				
	Lettuce	Spain	Myclobutanil	0.13	0.02	0.007	0.026	0.03	0.05				
	Lettuce	Ireland	Quintozene	0.1	0.02	0.007	0.026	0.01	0.12				
	Lettuce	Ireland	Demeton-S-methyl sulfone	0.22	0.05	0.007	0.026	0.0003	8.56	0.002	5		23.8
	Lettuce	Ireland	Dimethoate	0.65	0.5	0.007	0.026	0.002	3.8	0.03	5		5
			Iprodione	12.91	10	0.007	0.026	0.06	2.5				
	Spinach	Spain	Folpet	0.15	0.1	0.009	0.039	0.1	0.02				
Bean (+ pod)	Kenya	Dimethoate	0.1	0.02	0.013	0.038	0.002	1.1	0.03	7		1.5	
Bean (+ pod)	Ireland	Azoxystrobin	1.1	1	0.013	0.1	0.1	0.2					
Celery	United States	Permethrin	0.14	0.05	0.004	0.058	0.05	0.02					
		Propiconazole	0.06	0.05	0.004	0.058	0.04	0.01					
Potato	Ireland	Tecnazene	0.29	0.05	0.172	0.709	0.02	4.2					
2006	Apple	Chile	Dicofol	0.16	0.02	0.054	0.191	0.002	7.2	0.1	5	2.1	
	Blueberry	Chile	Fenvalerate	0.2	0.02	0.003	0.01	0.02	0.05				
	Carrot	Ireland	Chlorfenviphos	0.51	0.5	0.0004	0.001	0.0005	41	0.01	5	31	
	Carrot	Ireland	Chlorfenviphos	0.51	0.5	0.0018	0.005	0.0005	184	0.01	5	125	
	Celery	Spain	Procymidone	0.03	0.02	0.01	0.06	0.025	0.02	0.035	5	0.3	
	Courgette	Spain	Thiabendazole	0.06	0.05	0.01	0.38	0.1	0.01				
	Kiwi	Italy	Methidathion	0.04	0.02	0.02	0.1	0.001	1.3	0.01	5	3.2	
	Lettuce	Ireland	Demeton-s-methylsulfone	0.16	0.02	0.006	0.03	0.0003	5	0.005	5	6.9	
	Lettuce	Ireland	Azoxystrobin	3.72	3	0.006	0.03	0.1	0.4				
	Lettuce	Ireland	Dimethoate	3.86	0.5	0.0016	0.002	0.002	5	0.03	5	1.3	
	Lettuce	Ireland	Omethoate	0.5	0.14	0.0016	0.002	0.0003	1	0.004	5	28.2	
	Lettuce	Ireland	Dimethoate	3.86	0.5	0.0016	0.002	0.002	5	0.03	5	1.3	
	Lettuce	Ireland	Omethoate	0.5	0.49	0.0016	0.002	0.0003	4	0.004	5	98	
	Lettuce	Ireland	Cypermethrin	2.36	2	0.006	0.03	0.03	0.8				

Year	Commodity	Country of origin	Pesticide detected	Residue content (mg/kg)	MRL (mg/kg)	Commodity intake		ADI (mg/kg bw/day)	Intake as % of ADI	ARfD (mg/kg bw/day)	Variability factor	Intake as % of ARfD
						Mean (kg/day)	97.5%ile (kg/day)					
2006	Lettuce	Ireland	Omethoate	0.5	0.14	0.006	0.03	0.0003	5	0.004	5	7.6
	Lettuce	Ireland	Dimethoate	0.86	0.5	0.0005	0.002	0.002	22	0.03	5	22.9
	Lettuce	Ireland	Omethoate	0.5	0.14	0.0005	0.002	0.0003	23	0.004	5	28
	Lettuce	Ireland	Propyzamide	1.67	1	0.0001	0.002	0.02	0.92			
	Lettuce	Ireland	Propyzamide	1.67	1	0.0005	0.002	0.02	4.18			
	Lettuce	Ireland	Dimethoate	0.86	0.5	0.006	0.03	0.002	4	0.03	5	6.3
	Litchi	Thailand	Chlorpyrifos	0.1	0.05	0.004	0.006	0.01	0.07	0.1	5	0.1
	Mandarin	Cyprus	Thiabendazole	6.13	5	0.039	0.1	0.1	4			
	Mandarin	Peru	Procymidone	0.03	0.02	0.0007	0.003	0.025	0.09	0.035	5	0.8
	Mandarin	Peru	Procymidone	0.03	0.02	0.006	0.03	0.0003	5	0.004	5	7.6
	Mandarin	Peru	Procymidone	0.07	0.02	0.043	0.1	0.025	0.2	0.035	5	1.8
	Mandarin	Peru	Procymidone	0.07	0.02	0.0034	0.01	0.025	0.95	0.035	5	1.4
	Mango	Brazil	Azoxystrobin	0.1	0.05	0.003	0.01	0.1	0.01			
	Orange	Spain	Thiabendazole	6.92	5	0.078	0.3	0.1	9			
	Parsnip	Ireland	Linuron	0.21	0.2	0.013	0.05	0.03	1.5			
	Peach	Israel	Dimethoate	0.02	0.02	0.043	0.2	0.002	0.7	0.03	5	1
	Peach	Israel	Omethoate	0.04	0.02	0.043	0.2	0.0003	9.6	0.004	5	14.4
	Peach	Spain	Thiabendazole	0.06	0.05	0.043	0.2	0.1	0.04			
	Pineapple	Guatemala	Thiabendazole	0.54	0.05	0.021	0.09	0.1	0.2			
	Plum	Chile	Thiabendazole	0.09	0.05	0.01	0.187	0.1	0.02			
	Pomegranate	Spain	Chlorpyrifos	0.07	0.05	0.003	0.0002	0.01	0.04	0.1	5	0.1
	Pomegranate	Spain	Cypermethrin	0.15	0.05	0.003	0.0002	0.05	0.02	0.2	5	0.1
	Pomegranate	Spain	Chlorpyrifos	0.07	0.05	0.0002	0.0007	0.01	0.14	0.1	5	0.2
	Pomegranate	Spain	Cypermethrin	0.15	0.05	0.0002	0.0007	0.05	0.06	0.2	5	0.3
	Rambutan	Thailand	Cypermethrin	0.09	0.05	0.003		0.05	0.01			
	Satsuma	Peru	Procymidone	0.09	0.02	0.043	0.1	0.025	0.3	0.035	5	3.2
Spinach	Ireland	Carbendazim	0.25	0.1	0.009	0.04	0.02	0.2	0.02	5	5.7	
2007	Apple	Italy	Procymidone	0.03	0.02	0.00102	0.0032	0.025	0.9	0.035	5	6.8
	Lettuce	Ireland	Propyzamide	2.32	1.0	0.0001		0.085	0.3	NR		
	Apple	France	Carbendazim	0.37	0.2	0.0011	0.0032	0.02	2.0	0.02	5	20
	Parsnip	Ireland	Chlorfenviphos	0.66	0.5	0.00022	0.0008	0.001	14.5	0.01	5	26.4
	Celery	Spain	Thiophanate methyl	0.3	0.1	1.7x10 ⁻⁷	0.00001	0.08	0	0.2	5	0
			Fenitrothion	0.05	0.01	1.7x10 ⁻⁷	0.00001	0.005	0	0.04	5	0
	Orange	Spain	Carbendazim	0.14	0.1	0.0013	0.0046	0.02	0.9	0.02	5	10.8
	Mandarin	Cyprus	Thiabendazole	6.33	5.0	0.00072		0.1	0.3	NR		
			Imazalil	5.56	5.0	0.00072	0.0025	0.03	0.13	0.05	5	5.20
	Clementine	Spain	Fenitrothion	0.03	0.01	0.0007	0.0025	0.005	0.4	0.04	5	0.9
	Table Grapes	S. Africa	Dimethoate	0.03	0.02	0.003	0.0023	0.003	4.5	0.0038	5	2.6
	Celery	Spain	Fenitrothion	0.05	0.01	1.7x10 ⁻⁷	0.00001	0.005	0	0.04	5	0
	Celery	Spain	Fenitrothion	0.05	0.01	1.7x10 ⁻⁷	0.00001	0.005	0	0.04	5	0
	Lettuce	Ireland	Oxydemeton methyl	0.17	0.05	0.00011	0.00044	0.0003	6.2	0.002	5	18.7
	Broccoli	Guatemala	Dimethoate+	0.04	0.02	0.00026	0.0008	0.002	0.04	0.03	5	3.8
	Broccoli	Spain	Carbaryl	0.06	0.05	0.00026	0.0008	0.007	0.2	0.03	5	0.8
	Pepper	Israel	Methomyl	0.14	0.05	0.00136	0.00059	0.0025	7.6	0.0025	5	16.5
Pear	S. Africa	Methomyl	0.43	0.05	0.00067	0.0022	0.0025	11.5	0.0025	5	168.6	
Celery	Spain	Fenitrothion	0.04	0.01	0.00013	0.00078	0.005	0.1	0.004	5	0.2	

Year	Commodity	Country of origin	Pesticide detected	Residue content (mg/kg)	MRL (mg/kg)	Commodity intake		ADI (mg/kg bw/day)	Intake as % of ADI	ARfD (mg/kg bw/day)	Variability factor	Intake as % of ARfD
						Mean (kg/day)	97.5%ile (kg/day)					
2007	Pear	Belgium	Thiophanate-methyl	0.84	0.5	0.00067	0.0022	0.08	0.7	0.2	5	4.1
	Endive	Ireland	Deltamethrin	0.57	0.5	0.00009	0.00035	0.01	0.5	0.01	5	10.0
	Strawberry	Ireland	Pymetrozine	0.47	0.02	0.0002	0.0014	0.03	0.3	0.1	5	0.7
	Satsuma	S. Africa	Diphenylamine	0.12	0.05	0.00057		0.03	0.2	NR		
	Carrot	Spain	Ethion	0.04	0.01	0.0003	0.001	0.002	0.6	0.002	5	10.0
	Apple	UK	Carbendazim	2.26	0.2	2.7x10 ⁻⁴	0.00135	0.02	3	0.02	5	15.3
	Mango	Brazil	Prochloraz	7.61	5	0.00026		0.01	19.8	NR		
	Grapefruit	S. Africa	Captan	0.13	0.02	0.00098	0.0018	0.1	0.1	0.1	5	1.2
	Apple	UK	Carbendazim	0.45	0.2	0.00026	0.00135	0.02	0.6	0.02	5	3.0
	Passion Fruit	Kenya	Dicofol	0.11	0.02	0.0002		0.002	1.1	NR		
			Ethion	0.05	0.01	0.0002	0.002	0.002	0.5	0.002	5	0.5
	Strawberry	USA	Methomyl	0.07	0.05	0.0002	0.0014	0.0025	0.6	0.0025	5	3.9
	Apple	UK	Carbendazim	0.57	0.2	0.00026	0.00135	0.02	0.7	0.00135	0.02	3.8
	Apple	France	Fenitrothion	0.03	0.01	0.00071	0.0025	0.005	0.4	0.04	5	0.9
	Apple	Chile	Carbendazim	0.55	0.2	0.00071	0.0025	0.02	2.0	0.02	5	34.4
Orange	S. Africa	Captan	0.08	0.02	0.0013		0.02	0.005	0.1	5	1.2	
Turnip	Ireland	Chlorpyrifos	0.07	0.05	0.0022	0.00065	0.01	1.5	0.1	5	0.2	

(a) in the absence of intake data, an estimated intake level of 3 g per person per day was used

(b) in the absence of intake data, the 97.5 percentile intake was estimated by multiplying the mean intake by 3

occurrence in products labeled as organic suggest that the production systems in place did not conform with organic production requirements.

4.3.5 Processed Products

Between 2004 and 2007, 50 to 95 samples of processed fruit and vegetable juices and of processed cereal products were analysed for pesticide residues. Between three (2004) and twelve (2007) samples contained measurable pesticide residues but the residues found were at very low levels and did not exceed the MRLs established for the raw commodities from which the processed products were produced (Table 4.6). This relatively low incidence of residues in processed products may be due to fruit and vegetables for processing not being treated with plant protection products to the same extent as unprocessed products sold directly in the retail market, particularly late pesticide and/or post-harvest treatments.

Pesticide Control Service, Department of Agriculture and Food. 2000. Pesticide Residues in Food -1999. The Stationary Office, Dublin, ISBN 0-7076-9202-4.

Pesticide Control Service, Department of Agriculture and Food. 2001. Pesticide Residues in Food -2000. The Stationary Office, Dublin, ISBN 0-7076-9251-2.

Pesticide Control Service, Department of Agriculture and Food. 2002. Pesticide Residues in Food -2001. The Stationary Office, Dublin.

Pesticide Control Service, Department of Agriculture and Food. 2003. Pesticide Residues in Food -2002. The Stationary Office, Dublin.

Pesticide Control Service, Department of Agriculture and Food. 2004. Pesticide Residues in Food -2003. The Stationary Office, Dublin, ISBN 0-7557-1799-6.

Pesticide Control Service, Department of Agriculture and Food. 2006a. Pesticide Residues in Food -2004. The Stationary Office, Dublin, ISBN 0-7557-7380-2.

Pesticide Control Service, Department of Agriculture and Food. 2006b. Pesticide Residues in Food -2005. The Stationary Office, Dublin, ISBN 0-7557-1724-4.

Table 4.3 Results for Residue Testing of Cereals, 1999-2007

Year	No. Samples analysed	No. Domestic origin (%)	No. Imported origin (%)	No. Pesticides tested	Results determined			No. Pesticides detected
					No. ND (%)	No. < MRL (%)	No. > MRL (%)	
1999	39	23 (59.0%)	16 (41.0%)	94	36 (92.3%)	3 (7.7%)	0	3
2000	13	0 (0.0%)	13 (100%)	89	13 (100%)	0	0	0
2001	30	21 (70.0%)	9 (30.0%)	89	29 (96.7%)	1 (3.3%)	0	1
2002	47	31 (66.0%)	16 (34.0%)	89	46 (97.9%)	1 (2.1%)	0	1
2003	92	57 (62.0%)	35 (38.0%)	89 ^(a)	85 (92.4%)	6 (6.5%)	1 (1.1%)	4
2004	64	29 (45.3%)	35 (54.7%)	118	51 (79.7%)	13 (20.3%)	0	5
2005	67	34 (50.7%)	33 (49.3%)	148	58 (86.6%)	9 (13.4%)	0	4
2006	52	32 (61.5%)	20 (38.5%)	153	32 (61.5%)	15 (28.8%)	5 (9.7%)	8
2007	100	61 (61%)	39 (39%)	292	71 (71%)	29 (29%)	0	9

ND - not detected; < MRL - less than or equal to the relevant Maximum Residue Limit (MRL); > MRL - greater than the relevant MRL.

(a) 89 pesticides and metabolites were determined in samples for the first 9 months of 2003; this number increased to 113 for the final 3 months of 2003.

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4.4 An Bord Glas Quality Programme 1999-2002

An Bord Glas (Horticultural Development Board), as part of its role in establishing and enforcing grading and quality standards for horticultural produce, operated a quality programme. This quality programme was targeted at growers and pre-packers of fresh produce and encompassed all the main sectors of horticultural production, including field vegetables, mushrooms, soft and top fruit, protected crops and potatoes. Participation in the quality programme involved implementation of quality systems, part of which included sampling of horticultural produce following harvest at point of packaging or assembly. The samples were analysed for approximately 90 pesticides by an accredited laboratory. During the four years of this programme, 1999-2002, on average the samples were tested for 152 pesticides, including organochlorine, organophosphorus, dicarboximide, phthalimide, pyrethroid and other pesticides.

Table 4.7 provides a summary of the commodities and numbers of samples tested each year, the number of samples in which pesticide residues were determined and the number of samples found to contain residues above MRLs. Details of samples containing pesticide residues exceeding the MRLs are shown in Table 4.8. Over 20 different pesticides were determined on the various commodities over the four year period. Some of the more common pesticides found included carbendazim in mushrooms, lettuce and apples; chlorfenvinphos in parsnips, carrots and parsley; chlorothalonil in kale and celery; iprodione in lettuce, tomatoes and cabbage; omethoate in cabbage, lettuce and spinach; tecnazene in potatoes; triazophos in carrots and parsnips. However, most of these pesticide residues were below the relevant MRLs. Only four samples contained residues in excess of MRLs, as follows: chlorfenvinphos in carrots (1999), omethoate in cabbage (2000), triazophos in carrots (2001) and chlorothalonil in kale (2001).

Table 4.4 Results for Residue Testing of Foods of Animal Origin, 1999-2007

Year	Commodity	No. Samples analysed	No. Pesticides ^(a) tested	Results determined			No. Pesticides detected
				No. ND (%)	No. < MRL (%)	No. > MRL (%)	
1999	Bovine meat	75	52	73 (97.3%)	2 (2.7%)	0	1
	Ovine meat	50	52	35 (70.0%)	15 (30.0%)	0	5
	Porcine meat	86	52	84 (97.7%)	2 (2.3%)	0	2
	Dairy produce	50	54	50 (100%)	0	0	0
2000	Bovine meat	57	56	52 (91.2%)	5 (8.8%)	0	3 ^(b)
	Ovine meat	49	56	33 (67.3%)	16 (32.7%)	0	5
	Porcine meat	85	56	73 (85.9%)	12 (14.1%)	0	2
	Dairy produce	56	50	56 (100%)	0	0	0
	Venison	24	31	20 (83.3%)	4 (16.7%)	0	1
	Poultry	33	31	32 (97.0%)	1 (3.0%)	0	1
2001	Bovine meat	91	55	83 (91.2%)	8 (8.8%)	0	4
	Ovine meat	51	55	41 (80.4%)	10 (19.6%)	0	3
	Porcine meat	55	55	55 (100%)	0	0	0
	Dairy produce	58	55	58 (100%)	0	0	0
	Venison	11	31	10 (90.9%)	1 (9.1%)	0	1
	Poultry	45	31	37 (82.2%)	8 (17.8%)	0	3
2002	Bovine meat	130	55	123 (94.6%)	7 (5.4%)	0	2
	Ovine meat	48	55	44 (91.7%)	4 (8.3%)	0	2
	Porcine meat	52	55	50 (96.2%)	2 (3.8%)	0	2
	Dairy produce	54	55	54 (100%)	0	0	0
	Venison	2	55	2 (100%)	0	0	0
	Poultry	36	55	33 (91.7%)	3 (8.3%)	0	1
	Eggs	13	55	13 (100%)	0	0	0
	Honey	14	89	14 (100%)	0	0	0
2003	Bovine meat	127	55	123 (96.9%)	4 (3.1%)	0	2
	Ovine meat	69	55	52 (75.4%)	17 (24.6%)	0	4
	Porcine meat	71	55	71 (100%)	0	0	0
	Dairy produce	61	55	61 (100%)	0	0	0
	Poultry	27	55	23 (85.2%)	4 (14.8%)	0	1
	Eggs	10	55	10 (100%)	0	0	0
	Honey	7	89	7 (100%)	0	0	0
2004	Bovine meat	127	55	121 (95.3%)	6 (4.7%)	0	3
	Ovine meat	65	55	60 (92.3%)	5 (7.7%)	0	2
	Porcine meat	59	55	59 (100%)	0	0	0
	Dairy produce	67	55	67 (100%)	0	0	0
	Venison	5	55	5 (100%)	0	0	0
	Poultry	28	55	26 (92.9%)	2 (7.1%)	0	2
	Eggs	10	55	10 (100%)	0	0	0
	Honey	10	118	10 (100%)	0	0	0
2005	Bovine meat	121	55	113 (93.4%)	8 (6.6%)	0	2
	Ovine meat	71	55	64 (90.1%)	7 (9.9%)	0	3
	Porcine meat	69	55	66 (95.7%)	3 (4.3%)	0	3 ^(d)
	Dairy produce	60	55	60 (100%)	0	0	0
	Venison	9	55	9 (100%)	0	0	0
	Poultry	26	55	25 (96.2%)	1 (3.8%)	0	1
	Eggs	10	55	10 (100%)	0	0	0
	Honey	10	148	10 (100%)	0	0	0

Year	Commodity	No. Samples analysed	No. Pesticides ^(a) tested	Results determined			No. Pesticides detected
				No. ND (%)	No. < MRL (%)	No. > MRL (%)	
2006	Bovine meat	114	62	110 (96.5%)	4 (3.5%)	0	2
	Ovine meat	73	62	66 (90.4%)	6 (8.2%)	1 (1.4%)	4
	Porcine meat	63	62	60 (95.2%)	2 (3.2%)	1 (1.6%)	3
	Dairy produce	59	62	59 (100%)	0	0	0
	Venison	6	62	6 (100%)	0	0	0
	Poultry	23	62	21 (91.3%)	2 (8.7%)	0	2
	Eggs	11	62	11 (100%)	0	0	0
	Honey	10	153	10 (100%)	0	0	0
2007	Bovine meat	113	70	110 (97.3%)	3 (2.7%)	0	2
	Ovine meat	83	70	76 (91.6%)	7 (8.4%)	0	4
	Porcine meat	73	70	66 (90.4%)	7 (9.6%)	0	1
	Dairy produce	57	70	57 (100%)	0	0	0
	Venison	12	70	6 (50%)	6 (50%)	0	2
	Poultry	23	70	22 (95.7%)	1 (4.3%)	0	1
	Eggs	13	70	13 (100%)	0	0	0
	Honey	13	70	13 (100%)	0	0	0

(a) including 7 PCB congeners

(b) including 2 PCB congeners

(c) including 1 PCB congener

Table 4.5 Samples of Organic Products containing pesticide residues, 2004 - 2007

Year	Commodity	Country of Origin	Pesticide Detected	Residue Content (mg/kg)	MRL (mg/kg)
2004	Grapefruit	Spain	Dimethoate	0.04	0.02
	Lemon	Spain	Azoxystrobin	0.05	1
	Courgette	Spain	Endosulfan	0.02	0.05
	Lettuce	France	Oxadixyl	0.02	No MRL
2005	Courgette	Spain	Endosulfan	0.02	0.05
	Apple	Italy	Diphenylamine	0.03	5
	Carrot	Ireland	Iprodione	0.02	0.3
2006	Orange	S. Africa	Captan	0.02	0.1
	Orange	Uruguay	Malathion	0.02	2.0
	Pear	Spain	Diphenylamine	0.26	10
	Strawberry	Spain	Pirimicarb	0.03	No MRL
	Kiwi	Chile	Deltamethrin	0.05	0.05
	Carrot	Italy	Chlorpyrifos	0.03	0.1
	Courgette	Spain	Procymidone	0.04	1.0
2007	Broccoli	Italy	Carbaryl	0.04	1.0
	Apples	New Zealand	Maneb Group	0.06	3
	Strawberries	USA	Spinosad a/b	0.07	No MRL
	Parsnip	Israel	pp'-DDE	0.02	0.05
Mushroom	UK	Carbendazim	0.01	0.1	
		Prochloraz	0.07	2	

In summary, less than 25% of samples each year contained measurable residues of pesticides; 12%, 22%, 19% and 15% of samples tested in 1999, 2000, 2001 and 2002, respectively. These results are lower than were found for samples tested in the statutory pesticide monitoring programme (see sections 4.1-4.3 of this chapter), possibly reflecting the standard of production by participants in An Bord Glas Quality Programme and/or the domestic source of the produce.

4.5 Pesticides in Foods of Animal Origin (Teagasc)

Foods of animal origin, such as meat and dairy products, are open to two main sources of potential contamination from pesticide residues, either from direct application of a pesticide to the animal, for example spraying/dipping with insecticides, or from animals consuming feedstuffs which have been contaminated with pesticides. The two main classes of pesticides are organochlorine (OC) and organophosphorus

Table 4.6 Samples of Processed Products containing pesticide residues, 2004 - 2007

Year	Commodity	Country of Origin	Pesticide Detected	Residue Content (mg/kg)	MRL (mg/kg) for raw commodity
2004	Orange juice	Unknown	Thiabendazole	0.05	5
	Orange juice	Brazil	Carbendazim	0.1	5
			Thiabendazole	0.07	5
Orange juice	Unknown	Carbendazim	0.08	5	
2005	Orange juice	Cyprus	Thiabendazole	0.15	5
	Orange juice	Unknown	Thiabendazole	0.27	5
	Orange juice	Cuba	Thiabendazole	0.07	5
	Orange juice	Unknown	Dichlofluanid	0.04	5
	Apple juice	Unknown	Chlorothalonil	0.03	1
	Apple juice	UK	Diphenylamine	0.03	5
Oatbran	UK	Primiphos-methyl	0.03	5	
2006	Orange juice	Unknown	Imazalil	0.02	5.0
	Apple juice	Unknown	Carbendazim	0.1	2.0
	Apple juice	Unknown	Thiabendazole	0.09	5.0
	Pear, tinned	Italy	Fenhexamid	0.03	0.05
	Cranberry	USA	Cyprodinil	0.02	No MRL
	Oat flakes	Ireland	Chlorpropham	0.2	No MRL
	Pinhead oats	Ireland	Chlorpropham	0.09	No MRL
2007	Orange juice	Unknown	Carbendazim	0.01	0.5
	Orange juice	Unknown	Maneb	0.11	5.0
	Orange juice	Unknown	Imazalil	0.02	5.0
	Orange juice	Unknown	Thiabendazole	0.04	5.0
			Imazalil	0.06	5.0
	Orange juice	Unknown	Carbendazim	0.03	0.5
			Imazalil	0.04	5.0
	Orange juice	Unknown	Imazalil	0.02	5.0
	Apple juice	Unknown	Carbendazim	0.08	0.2
	Peach juice	Unknown	Carbendazim	0.01	0.1
	Cherry	USA	Captan	0.05	5.0
			Carbaryl	0.05	0.05
	Plum	Unknown	Iprodione	0.09	3.0
	Banana	Unknown	Azoxystrobin	0.22	2.0
Imazalil			0.04	2.0	
Raisin	USA	Propargite	0.02	No MRL	

Table 4.7 Commodities tested for pesticide residues in An Bord Glas Quality Programme, 1999-2002

Commodity	1999			2000			2001			2002		
	No. of Samples	No. positive for pesticides	No. > MRL for pesticides	No. of Samples	No. positive for pesticides	No. > MRL for pesticides	No. of Samples	No. positive for pesticides	No. > MRL for pesticides	No. of Samples	No. positive for pesticides	No. > MRL for pesticides
Apples	3						2			2	2	
Broccoli	4			2						6		
Brussels Sprouts	3						7	1		3		
Cabbage	15			10		1	18	2		6		
Carrots	4	2		7	5		4	2	1	5	1	
Cauliflower	4			3			5			6		
Celery	5	3		5	4		3	2		3	3	
Courgette	2											
Cress							1			1		
Cucumber				2	1		3			2		
Gooseberries				1								
Greens				2								
Kale	1						2		1			
Leeks	4			3			4			2		
Lettuce	5	3		6	5		6	6		4	3	
Mushrooms	62	3		53	7		38	10		49	6	
Onions	2			3			2			1		
Parsley	4	2					2			1	1	
Parsnips	5	1	1	4	4		2	2		3	1	
Potatoes	35	1		22			34	1		33	1	
Raspberries				1	1							
Rhubarb	1			1								
Scallions										1		
Spinach	1			1	1					1		
Sprouts				3								
Strawberries										1		
Swedes	4			4			3			3		
Thyme	1	1					1					
Tomatoes	9	1		8	2		9			10	1	
Turnips				1			1			1		

(OP) pesticides. Three studies were undertaken during 1997 on the occurrence of OC and OP pesticides in beef and pork fat and in dairy products (cheese and butter). For these twelve-month studies, 140 samples of beef fat, 132 samples of pork fat and 130 samples of cheese/butter were analysed for pesticide residues. In the case of beef fat, no measurable residues of OC pesticides were determined in any sample. In the case of pork fat, 128 samples (97%) showed no measurable residues of OC pesticides. Two samples contained Dieldrin at approximately 0.01 mg/kg (ppm),

which is 20 times lower than the MRL for that pesticide (0.2 mg/kg fat). Two further samples contained Lindane at 0.025 mg/kg, which is 40 times lower than the MRL for that pesticide (1.0 mg/kg fat). In the case of dairy products, only one sample contained Lindane at a level close to the limit of detection, 0.01mg/kg. No sample in any of the studies contained measurable residues of OP pesticides (less than 0.1 mg/kg). These results indicate that residues of the common OC and OP pesticides are not a problem in these foods of animal origin.

4.6 Pesticides in Infant Foods (FSAI)

The Food Safety Authority of Ireland (FSAI) carried out a surveillance study of infant food available on the Irish market for the possible presence of pesticide residues, in order to establish levels of compliance with existing and proposed legislation relating to pesticide residues in processed foods for infants and young children (Commission Directives 91/3/21/EEC and 96/5/EC). 41 samples of baby food were purchased from retail outlets in Dublin in August 2003, comprising infant formula, biscuits, juices and infant foods containing fruit, vegetables, meat and cereals. The samples were tested for 366 pesticides comprising organochlorine, organophosphorus, pyrethroid, carbamate, benzimidazole, organonitrogen, organotin, phenoxy-carboxylic acid and other pesticides and marker PCBs. Analysis of the samples was performed by the specialist laboratory Eurofins/Labor Specht & Partner, Germany.

Of the 41 samples tested for 366 pesticides, only 5 positive results were obtained (Table 4.9). Residues of the organochlorine pesticide dieldrin were determined in a vegetable/

meat baby dinner, at one-third the regulatory limit of 0.003 mg/kg. Piperonylbutoxide, used as a synergistic compound with pyrethroid insecticides, was determined in a fruit-based infant food at one-half the regulatory limit of 0.01 mg/kg. Three fruit and cereal-based products contained residues of o-phenylphenol at two to four times the regulatory limit of 0.01 mg/kg. o-Phenylphenol is a post-harvest fungicide but may be used also as a food preservative and may occur as a contaminant from food packaging materials. Investigations by FSAI with the manufacturers of the contaminated samples established that the source of o-phenylphenol was the food packaging materials and use of these materials has now ceased.

The results of the study indicate that infant food products did not contain pesticide residues above the regulatory limits. The problem with a contaminant from food packaging materials was addressed.

Food Safety Authority of Ireland. 2004. Report on surveillance of infant food for pesticide residues, FSAI, 19 pp.

Table 4.8 Samples found to contain pesticides above MRLs in An Bord Glas Quality Programme (1999-2002)

Year	Commodity	Pesticide	Residue Content (mg/kg)	MRL (mg/kg)
1999	Parsnips	Chlorfenvinphos	0.60	0.5
2000	Cabbage	Omethoate	0.84	0.5
2001	Carrots	Triazophos	0.10	0.02
2002	Kale	Chlorothalonil	0.24	0.01

Table 4.9 Pesticide residues determined in infant foods

Food product	Pesticide		
	Name	Content (mg/kg)	MRL (mg/kg)
Vegetable/meat dinner	Dieldrin	0.001	0.003
Fruit-based pudding	Piperonylbutoxide	0.005	0.01
Mixed fruit food	o-phenylphenol ^a	0.022	0.01
Banana-based food	o-Phenylphenol ^a	0.037	0.01
Cereal-based food	o-Phenylphenol ^a	0.032	0.01

^aidentified as packaging contaminant

Radioactivity Monitoring/ Surveillance Programmes

CHAPTER FIVE

The Radiological Protection Institute of Ireland (RPII) is the national organisation with regulatory, monitoring and advisory responsibilities in matters pertaining to ionising radiation. In particular the Institute concerns itself with hazards to health associated with ionising radiation and with radioactive contamination in the environment. Two major programmes which the RPII undertake on a yearly basis in support of their responsibilities are the *Environmental Radioactivity Surveillance Programme* and *Radioactivity Monitoring of the Irish Marine Environment*. These programmes cover a range of sources of radioactivity in the terrestrial and marine environments; only data relating to samples of drinking water, milk, foodstuffs and fish/shellfish are included in this report.

5.1 Environmental Radioactivity Surveillance Programme

5.1.1 Introduction

The principal objective of the *Environmental Radioactivity Surveillance Programme* is to assess the exposure to the Irish population arising from radioactivity in the Irish terrestrial environment. The programme includes the sampling and testing for radioactivity in air, drinking water and foodstuffs, as well as the continuous measurement of ambient external gamma dose rates. The sampling programme is undertaken in conjunction with Met Éireann, the Department of the Environment, Heritage and Local Government, the Department of Agriculture, Fisheries and Food, the Food Safety Authority of Ireland, local authorities and health boards. This programme also fulfils Irish obligations under Article 35 of the EURATOM Treaty whereby each Member State of the EU is required to monitor continuously levels of radioactivity in the environment, thus ensuring compliance with basic safety standards.

The sources of radioactivity in the terrestrial environment are both natural and artificial. Natural radioactivity has been present in the terrestrial environment since the formation of the earth. Radioactivity of artificial origin has come from the testing of nuclear weapons in the atmosphere, accidents such as at the Chernobyl nuclear reactor, and the routine discharge of radionuclides from nuclear installations. Once present in the environment, these radionuclides are available for uptake by crops, animals and water and so make their way into the food chain.

The testing of nuclear weapons in the atmosphere, which took place from 1945 until 1980, released artificial material directly into the environment. The radionuclides produced and globally dispersed in atmospheric testing and which persist in the environment today include strontium-90, carbon-14, and caesium-137, as well as plutonium-238, plutonium-239 and plutonium-240.

During the routine operation of nuclear installations such as nuclear power plants and reprocessing plants in the UK and elsewhere, radioactive material is released to the environment under the authorisation of national authorities. Typical discharges include krypton-85, which is a gas and can be detected in Ireland. Other radionuclides from these sources are generally not detectable in the terrestrial environment. However, following a major accident such as occurred in Chernobyl in 1986, a range of radionuclides may be detectable. For example, caesium-137 still persists in the Irish environment following the Chernobyl accident.

5.1.2 Methodology

Drinking Water

All public water supplies serving populations in excess of 10,000 are sampled at least once



every four years. Those supplies serving the major population centres are sampled annually. During the 11-year period 1997 to 2007, the water supplies in 25 counties were sampled on one to ten occasions. Where possible, drinking water is sampled at the point at which the treated water is released into the distribution network. Sampling is normally carried out on behalf of the RPII by the relevant local authority.

Milk

Particular importance is placed on the analysis of milk because of its importance as a foodstuff and because it serves as an indicator of radioactivity in the food chain, with radionuclides such as caesium-137 and strontium-90, which may have deposited on soil and grass, concentrating in milk. During the 11-year period 1997-2007, milk was sampled monthly at up to ten major milk-processing plants located in different counties.

Foodstuffs

Apart from milk, samples of dairy produce, beef, lamb, pork, poultry (1999-2007) and grain (2001-2007) originating from locations across the country were taken by local health boards and by food processors. Samples of complete meals, that is a three course prepared meal from restaurant outlets, were sampled during the period 2003 to 2006.

Food Ingredients

The radioactivity content of individual food ingredients was investigated by the RPII in a study carried out between 2003 and 2004 in collaboration with the Food Safety Authority of Ireland. Foodstuffs (including cereal and bakery products, dairy products, vegetables, fruit, meat, seafood, beverages, oils, preserves and sauces) were collected from supermarkets in Dublin.

Analysis

Analysis of samples was undertaken at the RPII's radio-analytical laboratory which is accredited by the Irish National Accreditation Board for a broad range of tests. Drinking water samples were tested for hydrogen-3 (tritium) by liquid scintillation counting and for gross alpha and gross beta activity by evaporation of the sample and gas flow proportional counting.

Table 5.1 Mean Gross Alpha and Beta Activities in Drinking Water, 1997-2007

County	Year	No. of Samples	Mean Gross Alpha ^a (mBq/l)	Mean Gross Beta ^a (mBq/l)
Carlow	1997	5	282	184
	1998	5	522	388
	2000	3	228	220
Cavan	2000	1	53	189
	2004	1	ND	167
Clare	2000	1	53	199
	2004	1	13	85
Cork	1997	1	ND	92
	1999	1	61	431
	2000	1	65	99
	2001	2	42	130
	2002	1	ND	130
	2003	8	25	249
	2004	1	ND	43
	2005	6	35	87
	2006	1	12	85
Donegal	2004	3	11	63
	2007	6	13	113
Dublin	1997	2	167	83
	1998	1	28	69
	1999	1	53	na
	2000	4	67	119
	2001	2	36	108
	2002	1	ND	59
	2003	1	7	37
	2005	22	27	66
	2006	14	45	103
	2007	4	15	69
Galway	1997	2	158	95
	1999	1	253	199
	2000	2	36	132
	2001	3	32	107
	2002	1	37	150
	2003	2	29	101
	2005	2	40	97
	2006	2	ND	69
Kerry	1997	1	22	102
	1998	2	99	121
	2000	1	43	121
Kildare	2003	3	8	209
	1998	1	281	145
	2000	2	115	189
	2003	2	19	67
	2004	1	11	32
Kilkenny	2005	1	58	141
	1998	2	ND	128
Laois	2000	1	67	143
	2004	1	60	81
Leitrim	1998	1	109	85
	2002	1	51	87

(Continued Over)

County	Year	No. of Samples	Mean Gross Alpha ^a (mBq/l)	Mean Gross Beta ^a (mBq/l)
Limerick	2000	1	57	182
	2001	1	33	98
	2002	2	49	185
	2003	1	ND	122
	2005	3	ND	74
	2006	9	83	101
	2007	7	13	121
Longford	2001	1	ND	48
Louth	1998	2	133	139
	2000	1	95	173
	2001	2	63	169
Mayo	1998	1	ND	61
	2002	1	ND	60
Meath	1997	1	109	122
	2001	1	47	149
Monaghan	1998	6	52	111
Roscommon	2002	5	63	173
Sligo	1998	2	44	64
	2002	4	55	86
Tipperary	1998	3	55	35
	2003	1	ND	2
Waterford	1998	4	56	75
	2003	2	17	101
Westmeath	1998	2	114	112
	2001	1	57	56
Wexford	2003	4	42	69
Wicklow	2003	7	13	54
	2004	1	ND	39
	2005	1	27	80

^aWhere individual samples show no measurable radioactivity (ND), those sample results are not included in the mean value
 ND - no radioactivity detected
 na - Sample(s) not analysed

Milk samples were tested for caesium-137 by high resolution gamma spectrometry, using high purity germanium detectors, and for strontium-90 by liquid scintillation counting. Foodstuffs were tested for caesium-137 by high resolution gamma spectrometry, using high purity germanium detectors.

5.1.3 Results

The results for the *Environmental Radioactivity Surveillance Programme, 1997- 2007* are presented in summary format in Tables 5.1 to 5.5. These tables give summary information only for the principal testing undertaken on drinking water, milk and foodstuffs; more detailed treatment

of the results is contained in the individual reports issued by RPII (see references) and available on the RPII website - www.rpii.ie.

Drinking Water

Table 5.1 gives the mean gross alpha activity and mean gross beta activity for drinking water for the period 1997 - 2007. The standard for drinking water, as set by EU directive 98/83/EC (transposed into Irish law in Statutory Instrument No. 439), specifies that the dose arising from one year's consumption of drinking water should not exceed 0.1 millisievert (mSv). The S.I. 439 requirements can be assessed using screening levels of 100 mBq/l for gross alpha activity and 1000 mBq/l for gross beta activity; only samples containing activity concentrations exceeding these levels require further investigation.

The gross beta activity concentrations in all the water samples were below the screening level of 1000 mBq/l, so no further investigations were required. In the case of gross alpha activity, 8 (1997), 9 (1998), 1 (1999), 3 (2000), 0 (2001), 1 (2002) and 0 (2003-2007) samples had gross alpha activity concentrations of greater than 100 mBq/l. These samples were further investigated by determining radium-226 and elemental thorium and uranium (1997 - 1998) and polonium-210 (1999 - 2002). Polonium-210 is a natural alpha emitting radionuclide with a high dose conversion factor relative to other natural radionuclides (117 mBq/l = 0.1 mSv). In the case of the 1997-1998 samples, the summed doses of the individual radionuclides (radium-226 and elemental thorium and uranium) were below the indicative dose of 0.1 mSv/year. In the case of the 1999 - 2002 samples, the values for polonium-210 were 0.09 - 2.19 mBq/l, that is significantly less than

Table 5.2 Range of Mean Caesium-137 and Strontium-90 Activity Concentrations in Milk, 1997-2007

County	Caesium-137 (Bq/l)	Strontium-90 (Bq/l)
Cavan	ND	ND-0.06
Cork	ND	ND-0.07
Dublin	ND	ND-0.05
Kerry	ND-0.53	ND-0.06
Kilkenny	ND	ND-0.06
Louth	ND	ND-0.06
Monaghan	ND	ND-0.04
Roscommon	ND-0.23	ND-0.06
Tipperary	ND	ND-0.07
Waterford	ND	ND-0.07

ND - no radioactivity detected

Table 5.3 Maximum Caesium-137 Activity Concentrations in a Range of Foodstuffs, 1999-2007

Sample Type	1999		2000		2001		2002	
	No. of Samples	Max Cs-137 (Bq/kg)	No. of Samples	Max Cs-137 (Bq/kg)	No. of Samples	Max Cs-137 (Bq/kg)	No. of Samples	Max Cs-137 (Bq/kg)
Dairy products	602	1.9	474	6.6	362	ND	348	12.2
Grain					12	ND	72	ND
Beef	108	ND	115	6.4	54	5.6	84	4.4
Lamb	68	17.8	72	5.2	82	10.8	84	6.6
Pork/Poultry	16	ND	56	1.9	30	ND	23	ND
Misc. foodstuffs					319	ND	250	ND
Sample Type	2003		2004		2005		2006	
	No. of Samples	Max Cs-137 (Bq/kg)	No. of Samples	Max Cs-137 (Bq/kg)	No. of Samples	Max Cs-137 (Bq/kg)	No. of Samples	Max Cs-137 (Bq/kg)
Dairy products	405	5.9	423	ND	463	5.1	563	4.0
Grain	114	ND	58	ND	6	ND	51	ND
Beef	48	1.4	35	8.1	36	ND	10	ND
Lamb	62	11.9	96	8.7	36	16.9	17	8.8
Pork/Poultry	56	ND	48	ND	11	ND	5	ND
Misc. foodstuffs	327	28.9	451	30.7	371	ND	249	2.9
Sample Type	2007							
	No. of Samples	Max Cs-137 (Bq/kg)						
Dairy products	466	3.02						
Grain	60	ND						
Beef/Pork/Poultry	9	ND						
Lamb	17	4.03						
Misc. foodstuffs	149	6.69						

ND - no radioactivity detected

would result in the total indicative dose of 0.1 mSv/year being exceeded. None of the 2003-2007 samples required to be further tested. All of the drinking water samples tested satisfied the provisions of S.I. 439.

Milk

Table 5.2 gives the range of mean caesium-137 and mean strontium-90 activity concentrations in milk for the period 1997 to 2007. Caesium-137 was detectable in only 7 samples during the 11-year period, at activity concentrations ranging from 0.13 to 0.53 Bq/l; these activities, at less than 1 Bq/l, are extremely low and give no cause for concern from a radiological point of view. Strontium-90

activity concentrations in milk ranged from non-detectable to 0.07 Bq/l over the 11-year period, again giving no cause for concern.

Foodstuffs

The maximum caesium-137 activity concentrations determined in various foodstuffs during the period 1999 to 2007 are shown in Table 5.3. Measurable activity was determined in some samples of dairy products and meat but no activity was detected in the majority of samples tested over the nine-year period. The maximum caesium-137 activity concentrations determined were ND-12.2 Bq/kg in dairy products, ND-8.1 Bq/kg in beef, 5.2-17.8 Bq/kg in lamb and ND-1.9 Bq/kg in

Table 5.4 Range of Caesium-137 Activity Concentrations in Complete Meals, 2003-2006

Location	2003		2004		2005		2006	
	No. of Samples	Cs-137 (Bq/kg)	No. of Samples	Cs-137 (Bq/kg)	No. of Samples	Cs-137 (Bq/kg)	No. of Samples	Cs-137 (Bq/kg)
Cork							2	ND
Dublin	4	ND	3	ND	3	ND	4	ND
Galway			12	ND			2	ND
Louth	11	ND – 0.95					3	ND

ND - no radioactivity detected

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Table 5.5 Caesium-137 Activity Concentrations in Food Ingredients, 2003-2004 (FSAI Study)

Dairy products		Vegetables		Cereal and Bakery Products	
Eggs (Fried)	ND	Potato Without Skin (Boiled)	ND	White Bread Rolls	ND
Whole Milk	ND	Potato With Skin (Microwaved)	ND	Brown Bread	ND
Skimmed Milk	ND	Onions (Fried)	ND	Plain Biscuit	ND
Semi-Skimmed Milk	ND	Tomatoes (Raw)	ND	Chocolate Biscuit	ND
Cream	ND	Carrots (Boiled)	ND	Cakes (Madeira)	ND
Cheese	ND	Frozen Peas (Boiled)	ND	Spaghetti (Boiled)	ND
Soft Cheese	0.24	Cabbage (Boiled)	ND	White Rice (Boiled)	ND
Yoghurt	ND	Broccoli (Boiled)	ND	Cornflakes	ND
Custard	ND	Cauliflower (Boiled)	ND	Bran Flakes	ND
Vanilla Ice Cream	ND	Lettuce Varieties (Raw)	ND	Breakfast Cereal (Wheat Type)	ND
Butter	ND	Mushrooms (Fried)	ND	Muesli	ND
Dairy Spreads	ND	Peppers (Raw)	ND	Oatflakes (Boiled)	ND
Meat		Celery (Raw)	ND	Breakfast Cereal (Rice Type)	ND
Pork (Grilled)	0.23	Swede (Boiled)	ND	Pizza	ND
Minced Beef (Fried)	ND	Cucumber (Raw)	ND	Quiches/Pies	ND
Beef Steak (Grilled)	ND	Sweetcorn (Boiled)	ND	Beverages	
Chicken (Roasted)	0.33	Green Beans (Boiled)	ND	Lager	ND
Turkey (Roasted)	ND	Carrots (Raw)	ND	Stout	ND
Lamb (Roasted)	0.75	Cabbage (Raw)	ND	Wine	ND
Offal (Fried)	0.60	Chips (Frozen)	ND	Spirits	ND
Pork Sausages (Grilled)	ND	Chips (As bought)	ND	Carbonated Soft Drinks	ND
White/Black Pudding (Fried)	ND	Canned Peas	ND	Fruit Squashes	ND
Bacon Rashers (Grilled)	0.41	Baked Beans	ND	Black Tea	ND
Ham (Raw)	ND	Canned Sweet Corn	ND	Coffee (Instant)	ND
Beefburgers (Grilled)	ND	Potato Crisps	ND	Coffee (Percolated)	ND
Beefburger (Whole as bought)	ND	Canned Tomato	ND	Water (Bottled)	ND
Fried Chicken (Whole as bought)	ND	Fruit		Apple Juice	ND
Preserves and Sauces		Apples	ND	Orange Juice	ND
Marmalade	ND	Oranges	ND	Seafood	
Fruit Jam	0.8	Bananas	ND	Mussels (Boiled)	ND
Honey	ND	Grapes	ND	Prawns	ND
Tomato Sauce	ND	Pears	ND	Crab	ND
Mayonnaise	ND	Raisins (Dried)	ND	Cod (Baked)	1.04
Gravy (Instant Granules)	ND	Peaches	ND	Salmon (Grilled)	0.32
Oils		Plums	ND	Smoked Salmon	0.49
Olive Oil	ND	Canned Peaches	ND	Canned Tuna	ND
Vegetable Oil	ND			Battered Fish (Whole as bought)	1.15

ND - no radioactivity detected

Table 5.6 Radioactivity in Various Fish Species^a, 1998-2006

Year	Sampling Location	Activity concentration, range (Bq/kg, wet weight)				
		Tc-99	Cs-137	C-14 ^b	Pu-238 ^b	Pu-239, 240 ^b
1998	Clogherhead	ND - 1.2	0.1 - 3.5			
	Howth	ND - 0.4	0.1 - 5.3			
	Dunmore East		0.1 - 2.0			
	Castletownbere		0.2 - 0.6			
	Galway		0.1 - 3.0			
	Killybegs		ND - 1.0			
1999	Clogherhead	ND - 1.6	0.2 - 3.1	22 - 53	ND - 0.0002	ND - 0.001
	Howth	ND - 0.2	ND - 4.0	24 - 28	ND	ND
	Dunmore East		0.2 - 2.3			
	Castletownbere		ND - 0.5			
	Galway		0.1 - 0.4			
	Killybegs		0.1 - 0.6			
2000	Clogherhead	ND - 1.0	0.1 - 3.4	23 - 32	ND - 0.0001	0.0002 - 0.0005
	Howth	ND - 0.5	ND - 5.7	19 - 25	ND	ND - 0.00004
	Dunmore East		0.2 - 6.5			
	Castletownbere		ND - 0.5			
	Galway		0.1 - 0.3			
	Killybegs		ND - 1.0			
2001	Clogherhead	ND - 2.2	ND - 5.3	28 - 36	ND	ND - 0.0016
	Howth	ND - 0.4	ND - 3.4	26 - 32	ND	ND - 0.0001
	Dunmore East		0.4			
	Castletownbere		ND - 0.5			
	Galway		ND - 1.3			
	Killybegs		ND - 0.4			
2002	Clogherhead	ND - 2.6	0.1 - 2.2	28 - 39	ND - 0.0004	ND - 0.0017
	Howth	ND - 0.4	ND - 2.2	26 - 35	ND	ND - 0.0001
	Dunmore East		0.1 - 0.7			
	Castletownbere		0.1 - 0.3			
	Galway		0.1 - 0.3			
	Killybegs		0.1 - 0.6			
2003	Clogherhead	0.15	0.2 - 3.0		ND	ND
	Howth	0.11	0.1 - 2.4		ND	ND
	Dunmore East		0.2 - 0.3			
	Castletownbere		ND - 0.8			
	Galway		0.1 - 0.9			
	Killybegs		0.1 - 0.5			
2004	Clogherhead	0.23	0.1 - 1.5		ND	ND
	Howth	0.21	ND - 2.1		ND	ND
	Castletownbere		0.1 - 0.7			
	Galway		ND - 0.3			
	Killybegs		0.04 - 0.5			
2005	Clogherhead	0.10	ND - 2.4		ND	0.0002
	Howth	ND	ND - 2.3		ND	ND
	Galway		ND - 0.1			
	Killybegs		ND - 0.3			
2006	Clogherhead	0.32	ND - 1.6		ND	
	Howth	2.7	0.1 - 1.9		ND	ND
	Killybegs		ND - 0.3			
	Kilmore Quay		0.3 - 0.4			
2007	Clogherhead	0.12	0.1 - 3.2		ND	0.0005
	Howth	0.06	ND - 2.3			
	Killybegs		0.1 - 0.7			
	Kilmore Quay		0.6 - 1.1			

^a Fish species: whiting, cod, plaice, ray, mackerel, herring (monkfish and lemon sole, also, from 2002 onwards)

^b Composite of samples collected during each year

ND - no radioactivity detected

pork/poultry. The origin of the caesium-137 detected in dairy products and meat is most likely to be fallout from the Chernobyl accident. The activity concentrations measured in foodstuffs are very low and do not pose a significant risk to health. Table 5.4 gives the range of caesium-137 activity concentrations in complete meals for the period 2003 to 2006. Caesium-137 was detectable in only three samples during the four-year period, at activity concentrations ranging from 0.21 to 0.95 Bq/kg.

Food Ingredients

The caesium-137 activity concentrations determined in the various food ingredients are shown in Table 5.5. Measurable activity was determined in one or more samples of dairy products, meat, seafood and preserves; in total, 11 of 104 samples showed measurable caesium-137 activity ranging from 0.23 to 1.15 Bq/kg fresh weight.

5.2 Radioactivity Monitoring of the Irish Marine Environment

5.2.1 Introduction

The primary objective of *Radioactivity Monitoring of the Irish Marine Environment* is to assess the exposure of the Irish population resulting from radioactive contamination of the Irish marine environment and to estimate the associated risk to health. In addition, the programme aims to assess the distribution of contaminating radionuclides and to identify long-term trends. The programme involves the routine sampling of and testing for radioactivity in fish, shellfish, seaweed, sediments and seawater. The RPII is assisted in the collection of samples by the Marine Institute and the Department of Communications, Marine and Natural Resources (currently Department of Agriculture, Fisheries and Food). The Oslo Paris (OSPAR) Convention sets out a framework for international cooperation on

the protection of the marine environment of the North-East Atlantic. In 1998, the OSPAR Contracting Parties agreed a strategy with the objective of preventing pollution of the maritime area from ionising radiation. This strategy was to be achieved through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of achieving concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances.

The most significant source of radioactive contamination in the Irish Sea is the discharge of low-level liquid waste from BNFL's nuclear fuel reprocessing plant situated at Sellafield. These discharges are authorised within prescribed limits by the UK Environment Agency. In addition to current discharges, the remobilisation from sediments of historic Sellafield discharges now makes an important contribution to the levels of radioactivity in the seawater of the western Irish Sea.

5.2.2 Methodology

Fish and shellfish were routinely collected from commercial landings at major Irish fishing ports. The fish species monitored over the ten-year period were whiting (*Merlangius merlangus*), cod (*Gadus morhua*), plaice (*Pleuronectes platessa*), herring (*Clupea harengus*), mackerel (*Scomber scombrus*) and ray (*Raja sp.*); from 2002 onwards, the additional fish species monkfish (*Squatina squatina*), and lemon sole (*Microstomus kitt.*) were sampled also. In the case of shellfish, those species monitored were prawns (*Nephrops norvegicus*), mussels (*Mytilus edulis*), lobster (*Homarus gammarus*) and oysters (*Crassostrea gigas*); from 2002 onwards, the additional shellfish species crab (*Cancer pagurus*) and scallops (*Pecten maximus*) were sampled also.

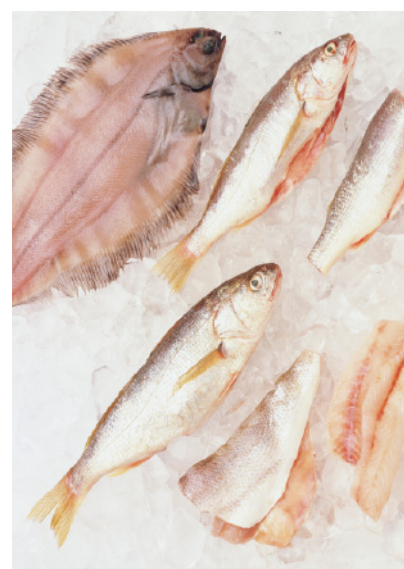
The samples of fish and shellfish were cleaned and the edible portion separated for

analysis. The samples were dried to constant weight and pulverised and thoroughly mixed. Individual samples were analysed for caesium-137 and selected individual and bulked samples were analysed for carbon-14, technetium-99, plutonium-238 and plutonium-239,240. Analysis of samples was undertaken at the RPII's radio-analytical laboratory which is accredited by the Irish National Accreditation Board for a broad range of tests. Samples were tested for caesium-137 and other gamma emitting radionuclides by high resolution gamma spectrometry, using high purity germanium detectors, for carbon-14 by high temperature catalytic combustion to carbon dioxide followed by liquid scintillation counting, for technetium-99 by radiochemical separation followed by beta spectrometry, using a gas flow proportional counter, and for plutonium-238 and plutonium 239,240 by radiochemical separation followed by alpha spectrometry, using silicon surface barrier detectors.

5.2.3 Results

The results for *Radioactivity Monitoring of the Irish Marine Environment, 1998- 2007* are presented in summary format in Tables 5.6 to 5.8 and in Figure 5.1. These tables and figure give summary information only for the principal testing undertaken on fish and shellfish; more detailed treatment of the results is contained in the individual reports issued by RPII (see references) and available on the RPII website – www.rpii.ie.

Table 5.6 and Table 5.7 show the range of activity concentrations determined in fish and shellfish, respectively, landed at the various ports over the ten-year period. Technetium-99 activity concentrations were generally observed to be higher in lobsters and prawns than in mussels and higher in mussels than in fish; this is consistent with the concentration factors reported for this radionuclide. The magnitude of the Sellafield contribution to the measured carbon-14 activities is masked by the presence of carbon-14 of natural origin and from weapons fallout.



For plutonium-238 and plutonium-239,240, activity concentrations were higher in shellfish than in fish; this is consistent with the concentration factors reported for plutonium.

From these data, the RPII estimated the radiation exposure dose to 'typical' (40g fish plus 5g shellfish per day) and to 'heavy' (200g fish plus 20g shellfish per day) consumers of seafood landed at the north-east ports of Carlingford, Clogherhead and Howth, where the highest concentrations of Sellafield derived radionuclides are usually found (Table 5.8). These dose estimates are calculated using the factors of annual consumption for fish and shellfish, and mean activity concentration and dose conversion for each radionuclide. The total dose was estimated to be 0.32 microsieverts (μSv) to 'typical' consumers in 1998, falling to 0.17 μSv in 2002, and remaining at that level between 2002 and 2007 (with the exception of 0.24 μSv in 2005). For 'heavy' consumers, the total dose was estimated to be 1.42 μSv in 1998, falling to 0.79 μSv in 2002 and remaining at that level between 2002 and 2007 (with the exception of 1.1 μSv in 2005). While these doses include contributions from technetium-99, caesium-137, plutonium-238, 239, 240 and americium-241, caesium-137 is the dominant radionuclide, accounting for up to 70% of the total dose due to artificial radionuclides in the marine environment. The high fraction of the total dose attributable to caesium-137 reflects the much higher dose conversion factor for this radionuclide compared with, for example, technetium-99.

The estimated committed effective dose to 'heavy' consumers of seafood due to radiocaesium, over the period 1982 to 2007, is shown in Figure 5.1; the dose to the Irish population due to caesium-137 has declined significantly over the last 26 years. For example, in the period 1982 to 2007, the estimated dose due to this radionuclide to heavy consumers has fallen from 70 μSv to 0.6 μSv , approximately. These doses may be put into context by comparing them with the dose attributable to the presence

Table 5.7 Radioactivity in various shellfish species^a, 1998-2006

Year	Sampling Location	Activity concentration, range (Bq/kg, wet weight)				
		Tc-99	Cs-137	C-14	Pu-238	Pu-239, 240
1998	Carlingford	6 - 433	0.2 - 0.7	15 - 31	0.006 - 0.043	0.033 - 0.238
	Clogherhead	ND - 103	0.1 - 1.0	21		
	Dunmore East	0.8	ND			
	Galway	0.5	ND - 0.1	14	ND	ND
	Howth	0.6 - 161	0.1 - 1.1	21	ND	0.001 - 0.012
1999	Lough Shinny	48 - 241				
	Bantry		0.2			
	Carlingford	2 - 72	0.1 - 0.6	11 - 21	0.014 - 0.035	0.057 - 0.182
	Castletownbere		0.2			
	Clogherhead	4 - 117	0.2 - 1.0	19		0.011
	Dundalk Bay	44				
	Galway		ND - 0.1	18	ND	0.001
	Howth	45 - 174	0.9 - 1.4	24	0.001 - 0.003	0.007 - 0.014
	Lough Foyle		0.2 - 0.4			
2000	Lough Shinny	33				
	Carlingford	3 - 47	0.2 - 0.9	18 - 24	0.007 - 0.036	0.036 - 0.217
	Castletownbere		ND			
	Clogherhead	64 - 147	0.8 - 1.5	22	0.003	0.015
	Dundalk Bay	41				
	Dunmore East		ND - 0.1			
	Galway		ND - 0.1	15	ND	0.003
	Howth	36 - 68	0.6 - 1.0		0.002 - 0.003	0.008 - 0.018
	Lough Foyle		0.1			
2001	Carlingford	2 - 51	0.1 - 0.4	23 - 35	ND - 0.030	0.033 - 0.174
	Castletownbere		ND			
	Clogherhead	2 - 68	0.1 - 1.6	35	0.014	0.067
	Dundalk Bay	17 - 63				
	Galway		ND		ND	0.0035
	Howth	22 - 322	0.1 - 3.3	28	ND - 0.036	0.001 - 0.204
2002	Carlingford	2 - 19	0.1 - 0.6	7.4 - 40	0.006 - 0.023	0.037 - 0.156
	Castletownbere		ND	16		
	Clogherhead	4 - 62	ND - 0.9	67	0.0002	0.0011
	Dundalk Bay	25 - 42	ND - 0.5			
	Galway		ND - 0.1	14 - 21	0.0002 - 0.004	0.002 - 0.022
	Howth	0.8 - 239	ND - 0.7	23 - 28	ND - 0.003	0.001 - 0.016
	Skerries	35 - 50	0.4 - 0.7			
2003	Bull Wall		0.3			
	Castletownbere		ND			
	Clogherhead	6 - 34	0.1 - 0.4		ND - 0.016	0.012 - 0.098
	Dundalk Bay		0.6			
	Galway		ND			
	Howth	21	0.1 - 0.7		ND	0.008
2004	Salthill		ND			
	Carlingford	4 - 40			0.006 - 0.023	0.034 - 0.130
	Castletownbere		ND			
	Clogherhead	30	ND - 0.8		0.003	0.013
	Galway		ND			
2005	Howth	28	0.1 - 0.7		ND	0.009
	Carlingford	3 - 36				
	Castletownbere		ND			
	Clogherhead	31	ND - 0.7			
	Galway		ND - 0.6			
2006	Howth	55	0.4 - 0.7		0.003	0.014
	Carlingford	0.3 - 2.3			0.006 - 0.016	0.056
	Clogherhead	23	ND - 0.6		ND	0.007
	Howth	10	ND - 1.1		ND	0.006
2007	Carlingford	1.3 - 6.7			0.006 - 0.009	0.033 - 0.055
	Clogherhead	15.14	ND-0.6		0.001	0.005
	Howth	1.64	0.1		ND	ND

^aThe shellfish species included are prawns, mussels, oysters and lobster, as follows:
 Bantry - mussels
 Bull Wall - mussels
 Dundalk Bay - lobster
 Dunmore East - prawns
 Lough Foyle - mussels
 Lough Shinny - lobster
 Skerries - lobster
 Carlingford - mussels, oysters, lobster
 Castletownbere - prawns, mussels
 Clogherhead - prawns, lobster, mussels, oysters
 Galway - prawns, mussels, scallops
 Howth - prawns, lobster, scallops, crab
 Salthill - mussels

ND - no radioactivity detected

Table 5.8 Estimated Radiation Exposure Dose (μSv) to Consumers of Seafood Landed at the Irish Sea North-East Ports, 1998-2006

Type of consumer	Year																			
	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007	
	Total	Cs-137	Total	Cs-137	Total	Cs-137	Total	Cs-137	Total	Cs-137	Total	Cs-137	Total	Cs-137	Total	Cs-137	Total	Cs-137	Total	Cs-137
Typical ^a	0.32	0.17	0.30	0.17	0.27	0.15	0.26	0.16	0.17	0.12	0.16	0.093	0.17	0.034	0.24	0.16	0.16	0.11	0.16	0.13
Heavy ^b	1.42	0.83	1.33	0.82	1.17	0.73	1.20	0.81	0.79	0.56	0.71	0.46	0.75	0.47	1.10	0.79	0.75	0.54	0.74	0.62

^a 40g fish plus 5g shellfish per day
^b 200g fish plus 20g shellfish per day

of the naturally occurring radionuclide, polonium-210, in seafood, which has been estimated to be 148 μSv for heavy seafood consumers. The estimated doses may also be compared with the annual average dose to a member of the Irish public of approximately 3620 μSv from all sources of radiation.

The doses incurred by people living in Ireland today as a result of the routine operations at Sellafield are small and do not constitute a significant health risk. The RPII's advice is that from a radiological perspective it is safe to eat seafood landed at Irish fishing ports and to enjoy the amenities of the Irish maritime area.

Reports

Results of the *Environmental Radioactivity Surveillance Programme* and of *Radioactivity Monitoring of the Irish Marine Environment* are published and reports are available online on the Radiological Protection Institute of Ireland's website (www.rpii.ie) free of charge.

Radioactivity Monitoring of the Irish Marine Environment 2007. RPII-08/02
 October 2008

Radioactivity Monitoring of the Irish Marine Environment 2006. RPII-07/3
 October 2007

Radioactivity Monitoring of the Irish Marine Environment 2003-2005. RPII-07/1
 May 2007

Radioactivity Monitoring of the Irish Marine Environment 2002. RPII-05/3
 December 2005

Environmental Radioactivity Surveillance Programme 2001 and 2002. RPII-05/2
 June 2005

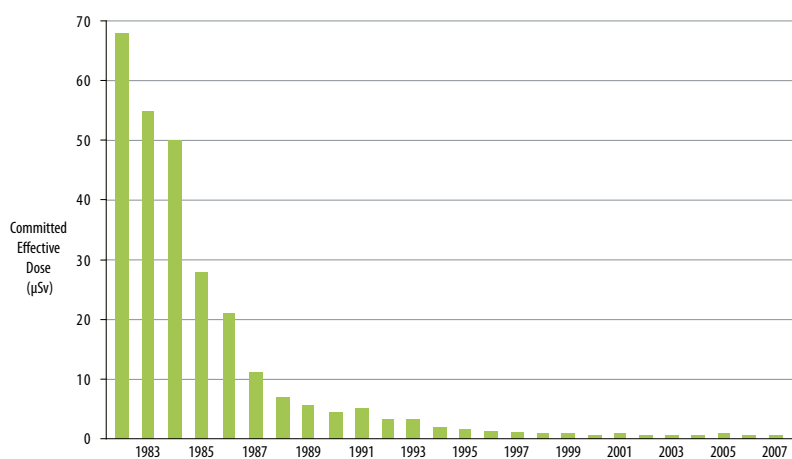
Radioactivity Monitoring of the Irish Marine Environment 2000 and 2001. RPII-03/3
 April 2003

Environmental Radioactivity Surveillance Programme 1999 and 2000. RPII-02/2
 February 2002

Radioactivity Monitoring of the Irish Marine Environment 1998 and 1999. RPII-00/1
 September 2000

Environmental Radioactivity Surveillance Programme 1997 and 1998. RPII-99/2
 December 1999

Figure 5.1 Doses to Heavy Seafood Consumers due to Radiocaesium (μSv), 1982-2007



Contaminants in Food: Residue Studies & Surveys

CHAPTER SIX

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6.1 Food Residue Database 1995 - 2000 (Teagasc)

Production of a database on the residue status of Irish foods - the Food Residue Database 1995-2000 - was a project aimed at developing residue information to be used by the Irish food industry to assist production, processing and marketing of food products. Irish food has a green and wholesome image. However, trading based on an image could not continue indefinitely. A need existed for comprehensive data to support this image, especially for customers of Irish products on the export market. The database was developed (a) to be used as a marketing tool to promote Irish food from a food safety point of view, (b) to demonstrate compliance of Irish products with regulations and with customer specifications, and (c) to identify potential or actual problems with production and processing practices, enabling early corrective action to be taken.

The database was comprised of a series of discrete studies, usually one year in duration, on foods of animal origin, such as meat products, dairy products and farmed fish, because of the importance of these products on the export market. The residues of interest were natural contaminants, agrochemicals, veterinary drugs and industrial contaminants. Within each study strict criteria were met to ensure the integrity of the database. The samples were randomly selected, were characteristic of the food on the export market and were seasonally and geographically representative of the production. In practice, samples were obtained on a regular basis directly from companies producing the products of interest. The samples were analysed by validated laboratory methods.

From the results of each study, reports were prepared for the food industry participants;

Table 6.1 Summary Reports on studies carried out for the Food Residue Database project

Dairy products
Heavy Metals in Dairy Powders, 1995/96
Aflatoxin M1 in Dairy Powders, 1996
Nitrates and Nitrites in Dairy Powders, 1996/97
Polycyclic Aromatic Hydrocarbons (PAHs) in Dairy Powders, 1996/97
Pesticide and PCB Residues in Butter and Cheese, 1997
Nitrates and Nitrites in Dairy Powders (Continuation Study), 1998/99
Dioxins and coplanar PCBs in Cheese, 1998/99
Beef products
β -Agonists in Bovine Liver, 1997/98
Pesticide and PCB Residues in Carcass Fat, 1997/98
Heavy Metals in Meat, 1997/98
Antibiotic Residues in Kidney, 1998/99
Polycyclic Aromatic Hydrocarbons (PAHs) in Carcass Fat, 1998/99
Pyrethroid Residues in Carcass Fat, 1999
Dioxins and coplanar PCBs in Carcass Fat, 2000
Pork products
Tetracycline Antibiotics in Meat and Kidney, 1996
Pesticide and PCB Residues in Carcass Fat, 1996/97
Tetracycline Antibiotics in Meat (Continuation Study), 1997/98
Heavy Metals in Meat, 1997/98
Ochratoxin A in Kidney and Meat, 1996/97 and 1999
Antibiotic Residues in Kidney, 1998/99
Polycyclic Aromatic Hydrocarbons (PAHs) in Carcass Fat, 1998/99
Dioxins and coplanar PCBs in Carcass Fat, 2000
Sheep Meat products
Pyrethroid Residues in Carcass Fat, 1999
Antibiotic Residues in Kidney, 1999/2000
Dioxins and coplanar PCBs in Carcass Fat, 2000
Poultry products
Antibiotic Residues in Kidney and Meat, 1999/2000
Coccidiostat Residues in Meat, 1999/2000
Dioxins and coplanar PCBs in Carcass Fat, 2000
Fish products
Ivermectin in Farmed Salmon, 1995/96
Ivermectin in Farmed Salmon (Continuation Study), 1997/98
Dichlorvos and Ivermectin in Farmed Salmon, 1999/2000

these reports were specific to each participating company, indicating the results for their samples. A Booklet of Summary Reports (Table 6.1) was also issued to food companies and agencies and a Final Report (Research Report No. 46, November 2001, ISBN 1 84170 2641) has been published by Teagasc.

The results of these studies have been described in the **National Food Residue Database Report 2005**, pages 39-47, ISBN 1 84170 397 4.

6.2 Dioxins, PCBs and Brominated Flame Retardants in Food and the Environment

6.2.1 Introduction

'Dioxins' is a collective term for the category of 75 polychlorinated dibenzo-para-dioxins (PCDDs) and 135 polychlorinated dibenzofurans (PCDFs). These substances occur mainly as unintentional by-products of incomplete combustion and from certain chemical processes. The toxicity of individual dioxin and dibenzofuran compounds (or congeners) varies considerably. The PCDD and PCDF congeners that are likely to be of toxicological significance are those 17 congeners with chlorine atoms at the 2,3,7 and 8 positions, the most toxic of which is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). The toxic responses include dermal effects, immunotoxicity and carcinogenicity, as well as reproductive and developmental toxicity.

Polychlorinated biphenyls (PCBs) are chlorinated hydrocarbons which were synthesised by direct chlorination of biphenyl, but production has now been discontinued. Depending on the number and location of the chlorine atom substituents, there are 209 possible PCB congeners. Of these, there are 12 non-ortho and mono-ortho substituted PCBs (77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189) that show similar toxicological properties to dioxins and are often termed 'dioxin-like PCBs'. The other PCBs exercise their toxicological effects in a different way and, because of the large number of possible congeners, the sum of the total level of six of the most-commonly occurring PCBs (28, 52, 101, 138, 153, 180) plus the level of the dioxin-

like PCB 118 is used as the value for the '7 indicator (or marker) PCBs', to give a measure of total PCB content.

Dioxins may be formed as unwanted by-products of the manufacture of some chlorinated compounds and, in small quantities, in a wide range of combustion processes where organic materials and chlorine compounds are burned together. Such sources can include incineration of all types of wastes, metallurgical operations such as smelting and scrap metal recovery furnaces and the burning of fuels such as coal, wood (especially where the wood contains preservatives) and petroleum products. Dioxin emissions from domestic fires are also believed to be a relatively significant source, particularly when wood or domestic waste is used on these fires. Dioxins are also found in paper products arising from the bleaching with chlorine of naturally occurring phenols present in wood pulp and in the manufacture of some chlorinated compounds.

Unlike dioxins, PCBs have found widespread use due to their physical and chemical properties, such as non-flammability, chemical inertia, high boiling points and high dielectric constants. PCBs have been used in pigments, sealants, rubber products and carbonless copy paper, and in hydraulic and heat transfer systems, transformers and capacitors. The production and use of PCBs has been discontinued or greatly reduced for some years but, because of their persistent qualities, they remain in electrical equipment, buildings and the environment.

Because samples contain dioxins as complex mixtures, a system of 'Toxic Equivalents' has been developed in order to express the dioxins and dioxin-like compounds as a composite figure for each sample. This procedure uses a scheme of weighting factors which expresses the toxicity of each individual PCDD and PCDF in terms of an equivalent amount of 2,3,7,8-TCDD. This weighting factor, called a toxic equivalent factor (TEF), is multiplied by the concentration of the individual compounds in a mixture to give a 2,3,7,8-TCDD toxic equivalent (TEQ) which is the sum of the concentrations of the individual congeners multiplied by their TEFs. A number of different systems for establishing



toxic equivalent factors exist: the NATO/CCMS (North Atlantic Treaty Organisation's Committee on Challenges of Modern Society) I-TEQ system and the newer system devised by the World Health Organisation (WHO) in 1998 that also incorporates PCBs. In calculating TEQs for compounds that are not found in concentrations above the limit of quantification, the current approach (as is applied in EU regulations) is to use values equivalent to the limit of quantification, the upper-bound values. This is a conservative approach to estimating TEQs at trace levels and can result in significantly higher estimates than the use of zero values for non-detected compounds in low level samples.

Brominated flame retardants (BFRs) are a group of chemicals that are added to many household products for fire prevention. Products such as clothing and textiles, furniture, computers and televisions contain BFRs such as polybrominated diphenyl ethers (PBDEs) and extruded and expanded polystyrene products contain the BFR hexabromocyclododecane (HBCD). PBDEs have a similar structure to PCBs, with bromine replacing chlorine. PBDEs have hormone disrupting properties and may be associated with reproductive disorders and

cancers. HBCD occurs as three diastereoisomers (α , β and γ), with the technical formulation consisting of approximately 80% γ -HBCD. HBCD is considered to be a potential environmental and consumer food safety concern.

6.2.2 Dioxin Levels in the Environment - Cows' Milk (EPA)

The EPA (Environmental Protection Agency) maintains surveillance of dioxins and dioxin-like compounds in the Irish environment.

Samples

Dioxins enter the food chain primarily through atmospheric deposition, including on to pasture. Because cows graze over relatively large areas and because dioxins, if present, will concentrate in the milk fat, cow's milk was chosen as a particularly suitable matrix for assessing the presence of dioxins in the environment. Four national surveys, based on cow's milk, have been undertaken, in 2000 (Concannon 2001), 2004 (Concannon 2005), 2006 (Concannon 2008) and 2007 (Concannon 2008). As far as possible, the same approach was adopted for the four surveys in terms of time of year and location of samples. For

Table 6.2 Dioxins and dioxin-like PCBs in milk (pg TEQ/g fat) - EPA surveys

	"Background" samples								
	1995	2000		2004		2006		2007	
	Dioxins (I-TEQ)	Dioxins (I-TEQ)	Dioxins + PCBs (WHO-TEQ)	Dioxins (I-TEQ)	Dioxins + PCBs (WHO-TEQ)	Dioxins (I-TEQ)	Dioxins + PCBs (WHO-TEQ)	Dioxins (I-TEQ)	Dioxins + PCBs (WHO-TEQ)
No. of Samples	20	24	24	24	24	24	24	24	24
Mean	0.23	0.20	0.49	0.16	0.37	0.22	0.45	0.21	0.386
Minimum	0.14	0.09	0.26	0.05	0.16	0.11	0.24	0.14	0.23
Maximum	0.50	0.35	0.95	0.33	0.66	0.64	1.06	0.30	0.52
	"Potential impact" samples								
	1995	2000		2004		2006		2007	
	Dioxins (I-TEQ)	Dioxins (I-TEQ)	Dioxins + PCBs (WHO-TEQ)	Dioxins (I-TEQ)	Dioxins + PCBs (WHO-TEQ)	Dioxins (I-TEQ)	Dioxins + PCBs (WHO-TEQ)	Dioxins (I-TEQ)	Dioxins + PCBs (WHO-TEQ)
No. of Samples	12	13	13	13	13	13	13	13	13
Mean	0.26	0.20	0.48	0.17	0.41	0.25	0.51	0.26	0.50
Minimum	0.13	0.09	0.27	0.10	0.22	0.11	0.26	0.16	0.28
Maximum	0.51	0.32	0.83	0.37	1.06	1.04	1.83	0.61	1.51

the 2000, 2004, 2006, and 2007 surveys, both dioxins and dioxin-like PCBs were determined. Samples of milk were taken in June/July for each survey, when cows could be expected to be grazing outdoors. Two types of milk samples were taken: type A samples (n=24, 2000, 2004 and 2006) were taken as representative of 'background' areas, covering the entire country; type B samples (n=12, 1995; n=13, 2000 - 2007) were taken as representative of 'potential impact' areas. Type A samples were normally taken from full milk silos (30-50,000 gallons) in regional dairies and type B samples were taken from road tankers representing the 'potential impact' areas. In 2006 and 2007, also, brominated flame retardants (BFRs) and brominated dioxins (PBDD/PBDFs) were determined. Five pooled samples, each consisting of three individual samples from different areas of the country, were analysed for a range of BFRs and PBDD/PBDFs.

Analysis

Analysis of the milk samples for dioxins was undertaken in specialist laboratories abroad - Gesellschaft für Arbeitsplatz und Umweltanalytik, Munster, Germany in 2000, 2004, 2006 and 2007. For the four surveys the analytical methods applied were broadly similar, involving solvent extraction of fat from the milk, separation of fat from the dioxins by dialysis and/or multiple chromatographic columns, and determination of the individual dioxin and dioxin-like PCBs by capillary column gas chromatography with high-resolution mass spectrometry. ¹³C-labelled isomers of the various dioxins and dioxin-like PCBs were used as internal standards for accurate quantification of the residue content in each milk sample.

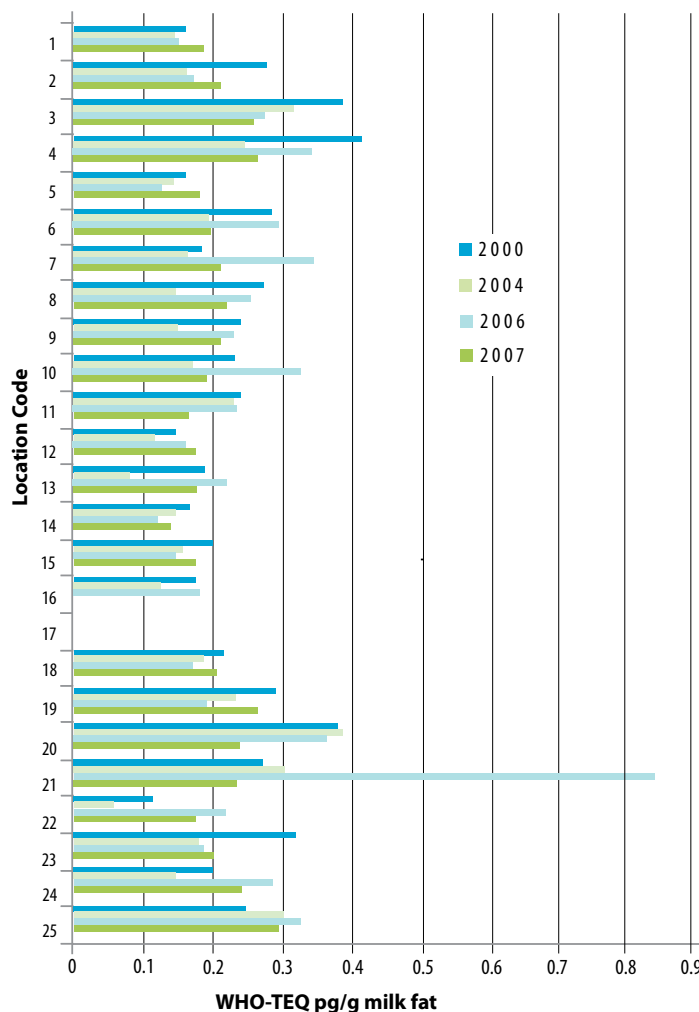
Results

A summary table of results for the four surveys is given (Table 6.2), together with figures showing comparisons for individual samples for the four surveys (Figures 6.1, 6.2). No significant differences in the dioxin levels, or in the dioxin plus PCB levels (2000, 2004, 2006 & 2007 surveys), were found between 'background' and 'potential impact' samples in the surveys. No discernible geographical pattern for dioxin content was evident in the 1995 survey. Some evidence of particularly low values for samples taken in the south-west (and other rural areas) was found in

the 2000 and 2004 surveys, together with the highest values being found in samples taken from areas along the east coast. In the 2006 survey, there is evidence of effects due to human activity in samples taken near to urban areas, especially in the Greater Dublin Area where dioxin values of 0.85 pg WHO-TEQ/g fat (0.64 pg I-TEQ/g fat - sample no. 21, Figure 6.1) and 1.31 pg WHO-TEQ/g fat (1.04 pg I-TEQ/g fat - sample no. 8, Figure 6.2) were determined.

Relative to levels of dioxins and PCBs in milk and milk products determined in other European countries, the levels found in these surveys are low and are considerably lower than the maximum levels specified

Figure 6.1 Comparison of the WHO-TEQ dioxin milk fat background samples



in EU regulations of 3 pg WHO-TEQ/g fat for dioxins/furans and 6 pg WHO-TEQ/g fat for dioxins/furans plus dioxin-like PCBs (Commission Regulation (EC) No. 1881/2006). The results obtained in these surveys are broadly comparable with the results obtained for the study on dioxins and PCBs in cheese carried out as part of the Food Residue Database project (see section 6.2.3 of this chapter).

Results for the composite samples tested for BFRs and PBDD/PBDFs in the 2007 survey are shown in Table 6.3. Only PBDE-type BFRs and PBDD/PBDFs were detected in the samples. The sum of PBDEs ranged from 95 to 279 pg/g fat for the five samples, levels that are relatively low by international comparisons. For the brominated dioxins (PBDD/PBDFs), values ranged from 0.13 to 0.30 pg WHO-TEQ/g fat. While there are no maximum limits set for PBDD/PBDFs, in view of their structural and toxicological similarities it is usual to adopt for guidance purposes the equivalent limits for PCDD/PCDFs in milk. None of the PBDD/PBDF values for the composite samples exceeded these limits.

Reports

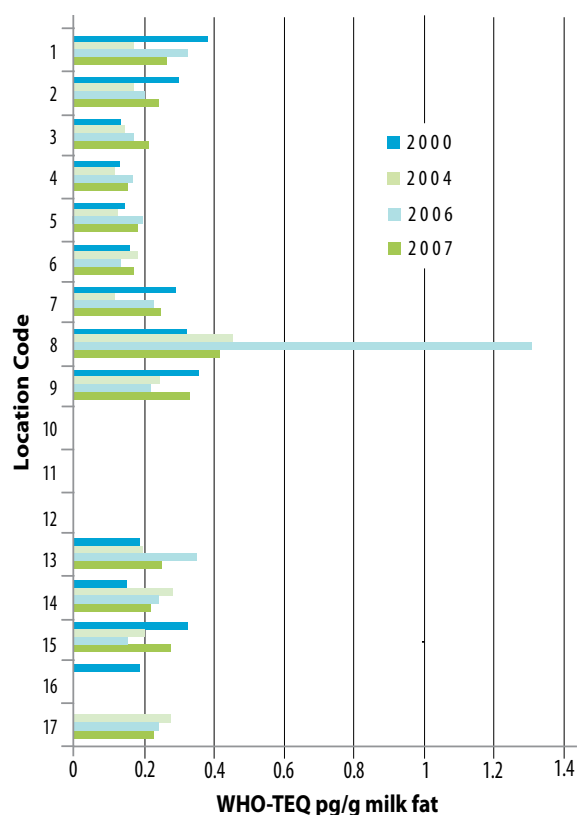
The results of the surveys are published by the EPA as four publications (Concannon 2001, 2005, 2008, 2009):

Concannon, C. 2001. Dioxin Levels in the Irish Environment: Second Assessment (Summer 2000) Based on Levels in Cows' Milk. Environmental Protection Agency, Wexford. ISBN 1-84095-056-0.

Concannon, C. 2005. Dioxins in the Irish Environment: Third Assessment (Summer 2004) Based on Levels in Cows' Milk. Environmental Protection Agency, Wexford. ISBN 1-84095-172-9.

Concannon, C. 2008. Dioxin Levels in the Irish Environment: Fourth Assessment

Figure 6.2 Comparison of the WHO-TEQ dioxin milk fat-potential impact samples



(Summer 2006) Based on Levels in Cows' Milk. Environmental Protection Agency, Wexford. ISBN 1-84095-263-6.

Concannon, C. 2009. Dioxin Levels in the Irish Environment: Fifth Assessment (Summer 2007) Based on Levels in Cows' Milk. Environmental Protection Agency, Wexford. ISBN 978-1-84095-299-5.

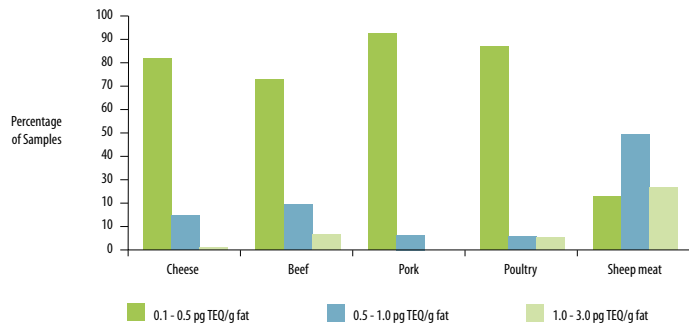
Table 6.3 Brominated Flame Retardants and Brominated Dioxins in Milk – EPA Survey 2007

	Composite Sample No.					Mean
	1 (Cork)	2 (Midlands region)	3 (West region)	4 (East region)	5 (North/Northwest region)	
PBDEs (pg/g fat)	138	123	95	127	279	152
PBDD/PBDFs (pg WHO-TEQ/g fat)	0.296	0.133	0.172	0.132	0.145	0.176

6.2.3 Dioxins and Dioxin-like PCBs in Dairy Products and Meat (Teagasc)

In 1998, the only previous substantial study on dioxins in Ireland had been by the EPA (Environmental Protection Agency) in 1995 on milk (see section 6.2.2 of this chapter), so it was decided to undertake studies on dioxins and dioxin-like PCBs in dairy products (cheese) and in meat (beef, pork, poultry and sheep). The study on cheese examined 90 samples from seven dairy companies during the period September 1998 to August 1999. Because of the specialised equipment and expertise required, these analyses were undertaken by the RIKILT laboratory in Wageningen, The Netherlands. The range of values in cheese samples for dioxins was from less than 0.1 to 0.8 pg WHO-TEQ/g fat, for dioxin-like PCBs was from less than 0.1 to 0.5 pg WHO-TEQ/g fat and for dioxins and dioxin-like PCBs combined was from 0.1 to 1.2 pg WHO-TEQ/g fat. A maximum value of 1.2 pg WHO-TEQ/g fat may be regarded as satisfactory, with values of 0.5 to 3.5 pg WHO-TEQ/g fat being reported for milk fat from other European countries and a maximum level of 3 pg WHO-TEQ/g fat being specified by EU regulations for dioxins in milk and milk products (Commission Regulations 2375/2001 and 684/2004) and 6 pg WHO-TEQ/g fat for dioxins/furans plus dioxin-like PCBs (Commission Regulation (EC) No. 199/2006, effective 4th November 2006).

Figure 6.3 Dioxins and Dioxin-like PCBs in foods of animal origin



A further study on carcass fat from the four main meat species was undertaken between January and July 2000. 15 samples each of beef, pork, poultry and sheep fat, from 13 meat processing companies, were tested for dioxins and dioxin-like PCBs. All samples of beef, pork and poultry fat contained dioxins and dioxin-like PCBs combined at less than or equal to 1 pg WHO-TEQ/g fat. In the case of sheep fat, some samples contained dioxins and dioxin-like PCBs at levels up to 3 pg TEQ/g fat. European regulations specify maximum levels for dioxins/dioxins plus dioxin-like PCBs of 3/4.5 pg WHO-TEQ/g fat for beef and sheep meat, 2/4 pg WHO-TEQ/g fat for poultry meat and 1/1.5 pg WHO-TEQ/g fat for pork. The Food Residue Database studies (Figure 6.3) indicate that Irish meat products meet these standards.

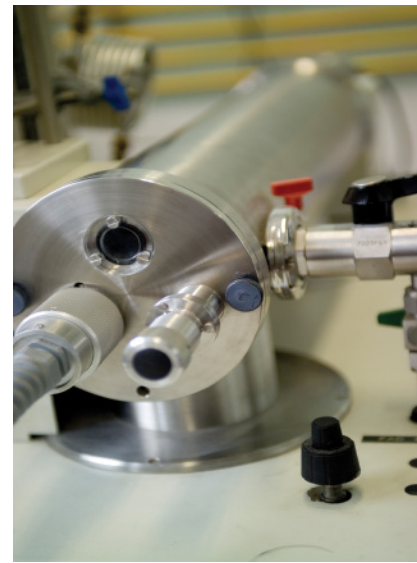
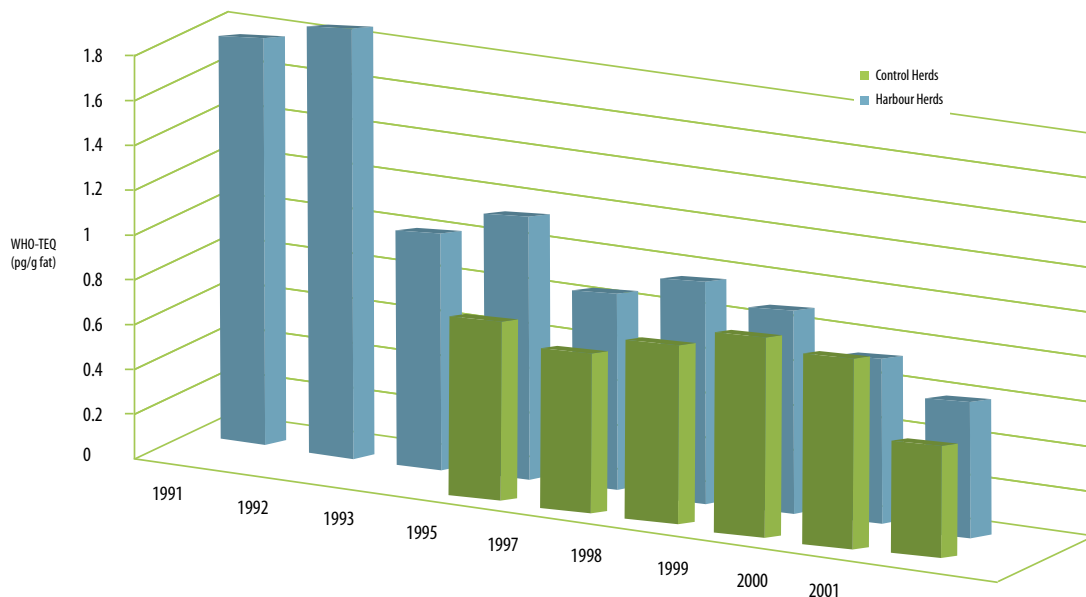


Figure 6.4 Dioxins and dioxin-like PCBs in milk samples, 1991- 2001



6.2.4 Dioxins PCBs and Brominated Flame Retardants in Food (FSAI)

The Food Safety Authority of Ireland (FSAI) has carried out surveillance studies on levels of dioxins, PCBs, PBDEs and HBCD in various foods and food products. Five studies are described here: (a) investigation on dioxins/furans and several PCBs in milk samples, 1991-2001; (b) investigation of dioxins, furans and PCBs in farmed salmon, wild salmon, farmed trout and fish oil capsules, 2001; (c) investigation into levels of dioxins, furans and PCBs in battery, free-range, barn and organic eggs, 2003; (d) investigation into levels of dioxins, furans, PCBs and PBDEs in Irish food, 2003; (e) investigation into levels of dioxins, furans, polychlorinated biphenyls and brominated flame retardants in fishery produce, 2004.

Milk

The study was carried out on milk samples ($n = 15$) from the tissue culture data bank collected by Cork County Council over a ten year period spanning 1991 to 2001. The samples included annual milk samples collected from designated herds in the Cork Harbour area from 1991 to 2001 and from control herds from 1995 to 2001. The study was designed to examine possible changes in dioxin and PCB levels in the Cork Harbour area, likely to be present due to the high concentration of chemical and pharmaceutical industries in the harbour region. The samples were tested for dioxins and PCBs in the specialist laboratory ERGO Forschungsgesellschaft mbH, Hamburg, Germany.

The results show a decrease in dioxin and PCB levels of over 60% in the Cork Harbour area during the period 1991 to 2001; dioxin/furan levels decreased from 0.81 to 0.31 pg WHO-TEQ/g fat and dioxin/furan plus dioxin-like PCB levels decreased from 1.7 to 0.57 pg WHO-TEQ/g fat (Figure 6.4). During the period 1995 to 2001 the dioxin and PCB levels in samples of milk from the Cork Harbour herds were, on average, 17% higher than the levels in samples of milk from the Control herds. All levels of dioxins determined in milk samples are much lower than the current EU regulation specifying a maximum level of 3 pg WHO-TEQ/g fat.

Fish and Fish Products

One study was carried out on 15 samples

each of farmed salmon, wild salmon, farmed trout and fish oil capsules, collected in 2001. All fish samples (provided by the Marine Institute) were either produced or landed in Ireland and the fish oil capsules (provided by the Irish Health Trade Association and some retail outlets) represented the top selling retail brands in Ireland. The second study was carried out on 70 samples of farmed salmon, wild salmon, fresh herring, mackerel, tuna and shellfish, smoked salmon and canned salmon, tuna, herring, sardines and mackerel, collected in 2004. The purpose of the studies was to examine how the levels of dioxins and PCBs (and, in the case of the second study, brominated flame retardants) in fish and fish products compared to the maximum levels specified in EU regulations. Dioxin, PCB and BFR contamination of fish and fish products may occur from the environment and in the case of farmed fish, also from fish feed containing fish oil sourced from wild fish stocks in contaminated areas of the sea. The samples of fish and fish products were tested in the specialist laboratory ERGO Forschungsgesellschaft mbH, Hamburg, Germany (2001 study) and in Eurofins Europe (GfA), Germany and the Central Science Laboratory (CSL), York, England (2004 study).

The results for the 2001 study (Table 6.4) for fish show that all samples of wild salmon, farmed salmon and farmed trout contained dioxins at levels considerably below the maximum level of 4 pg WHO-TEQ/g wet weight specified by EU regulation. The combined dioxins and dioxin-like PCBs were below the maximum level of 8 pg WHO-TEQ/g wet weight, specified by EU regulation. Farmed salmon showed the highest levels of dioxins and dioxin-like PCBs with a mean combined value (4.0 pg WHO-TEQ/g wet weight) equivalent to 50% of the maximum level; the sample containing the highest levels of dioxins and dioxin-like PCBs (6.3 pg WHO-TEQ/g wet weight) was at 80% of the maximum level. The results for fish oil (Figure 6.5) show that only one-third of samples were below the maximum level specified for dioxins in fish oils (2 pg WHO-TEQ/g fat) and that only one-quarter of samples were below the maximum level for dioxins and dioxin-like PCBs combined. Analysis of market share data indicated that only approximately 10% of the market for fish oil capsules is supplied by brands that had dioxin levels in excess of the maximum level.



Table 6.4 Dioxins and dioxin-like PCBs in fish (pg WHO-TEQ/g wet weight)

	Wild Salmon		Farmed Salmon		Farmed Trout	
No. of Samples:	15		15		15	
	Dioxins	PCBs	Dioxins	PCBs	Dioxins	PCBs
Mean	0.34	0.72	0.87	3.15	0.32	1.04
Minimum	0.14	0.52	0.59	1.75	0.17	0.60
Maximum	0.61	1.23	1.50	4.82	0.55	1.43
Standard deviation	0.128	0.214	0.242	0.869	0.121	0.252

The results for the 2004 study on dioxins and dioxin-like PCBs are shown in Figure 6.6; the data for wild salmon and farmed salmon from the 2001 study are included for comparison purposes. The highest values for dioxins and dioxin-like PCBs combined were found in farmed salmon, and these values were, for both studies, significantly higher than the values for wild salmon. The mean values for dioxins and dioxin-like PCBs in farmed salmon are lower by 38% and 50%, respectively, between the 2001 and 2004 studies; this may be due to changes in feed and feed management in farmed salmon production in the intervening period. For all sample types in the 2004 study, the levels of dioxins

and dioxins and dioxin-like PCBs combined are much lower than the maximum levels of 4.0 and 8.0 pg WHO-TEQ/g wet weight, respectively. Mean values ($\mu\text{g}/\text{kg}$) for the 7 indicator PCBs were 17.1 (farmed salmon), 10.6 (smoked salmon), 8.7 (fresh tuna), 8.0 (fresh mackerel), 7.7 (fresh herring), 5.5 (wild salmon), 1.2 (oysters) and 0.1 to 5.9 (tinned fish); these levels are substantially below maximum levels set in some EU Member States.

The results for the 2004 study for the brominated flame retardants, PBDEs, are shown in Figure 6.7. Farmed and smoked salmon were found to contain the highest

Figure 6.5 Dioxins and dioxin-like PCBs in fish oil capsules

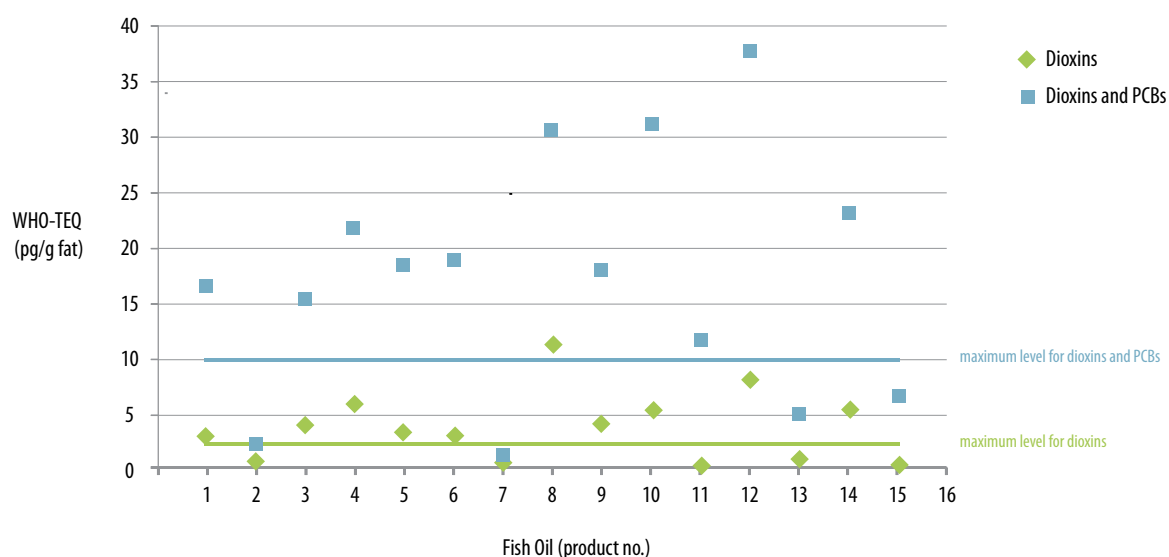


Figure 6.6 Mean concentrations for Dioxins and dioxin-like PCBs in fish and fish products, 2004 study (for wild salmon and for farmed salmon, values from a 2001 study are shown for comparison)

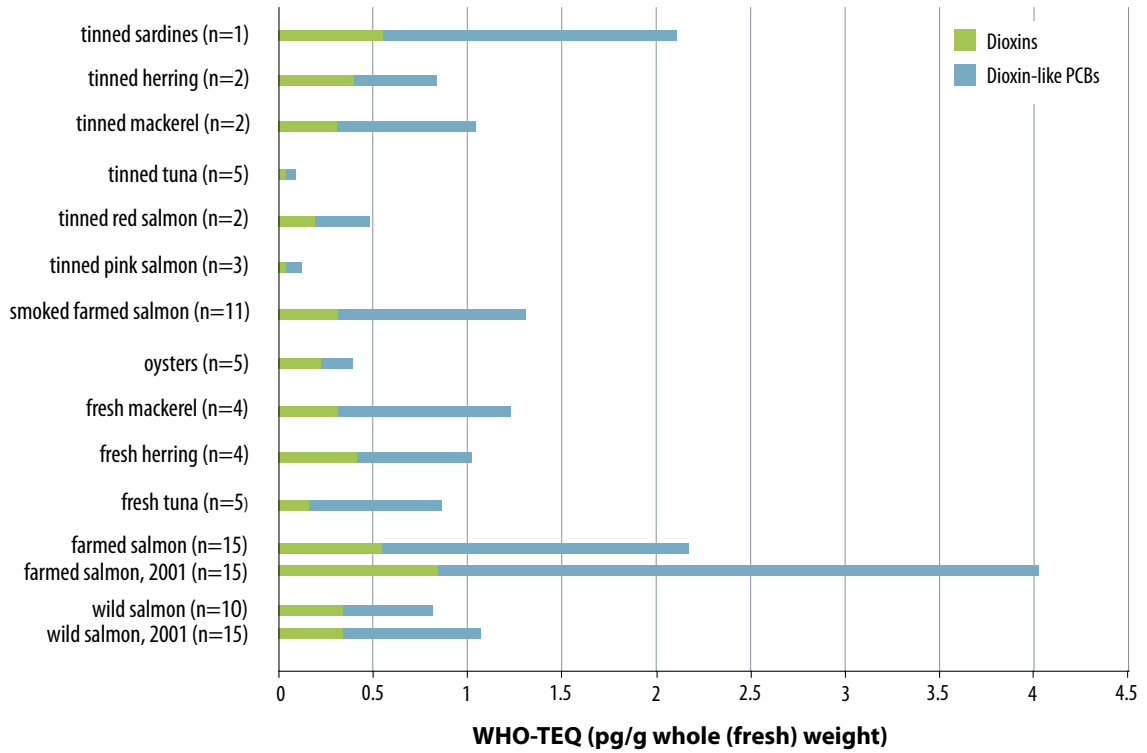


Figure 6.7 Concentrations for sum of PBDEs in fish and fish products, 2004 study

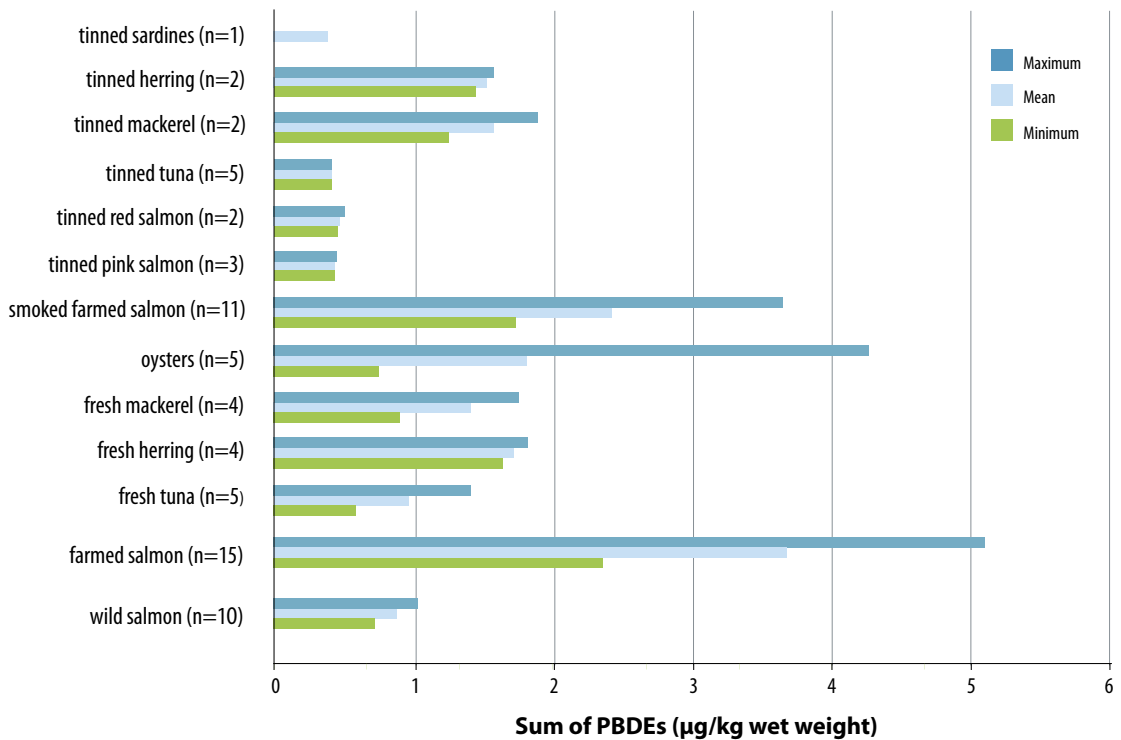


Table 6.5 Dioxins and dioxin-like PCBs in eggs (pg WHO-TEQ/g fat)

Type:	Battery		Free range		Organic		Barn	
No. of Samples:	16		16		4		4	
	Dioxins	PCBs	Dioxins	PCBs	Dioxins	PCBs	Dioxins	PCBs
Mean	0.36	0.29	0.47	0.32	1.30	1.43	0.31	0.27
Minimum	0.10	0.26	0.19	0.22	0.48	0.36	0.18	0.25
Maximum	0.58	0.37	0.83	0.43	2.70	3.93	0.51	0.28

levels for sum of PBDEs; the much higher levels compared to wild salmon may be due to the feed used. Differences in levels determined in fresh salmon and fresh tuna compared to tinned salmon and tinned tuna may be due to differences in species and/or geographic origin. A selection of individual samples were analysed for HBCDs; total HBCD content ($\mu\text{g}/\text{kg}$ wet weight) ranged from 1.08-2.67 (farmed salmon, n=4) to 1.01 (tinned mackerel), 0.68 (smoked salmon), 0.31 (fresh tuna) and <0.10 (tinned salmon and tinned tuna, n=2).

Eggs

The study was carried out on 40 samples of eggs provided by officers of the Egg and Poultry Division of the Department of Agriculture and Food. 30 of the samples were from individual producers and 10 of the samples were pooled samples from a number of different producers. For both free range and battery eggs, 16 samples each were taken, whereas for barn and organic eggs, for which categories there is low production in Ireland, four samples each were taken. 30 samples were taken from egg packing stations in Monaghan, Meath, Westmeath and Louth and 10 samples were taken from retail outlets in Dublin. The purpose of the study was to examine how the levels of dioxins and dioxin-like PCBs in eggs compared to the maximum levels specified in EU regulations. The samples of eggs were tested for dioxins and PCBs in the specialist laboratory CSL, York, UK.

The results (Table 6.5) show broadly similar levels of dioxins and dioxin-like PCBs in eggs from battery, free range and barn production systems. None of the eggs from these productions systems contained dioxins/furans at greater than 30% of the EU specified

maximum level of 3 pg WHO-TEQ/g fat. The highest level of dioxins/furans and dioxin-like PCBs combined determined in eggs from these production systems was at approximately 20% of the EU specified maximum level of 6 pg WHO-TEQ/g fat. Only in the case of organic eggs were relatively high levels of dioxins and dioxin-like PCBs observed. One sample contained 2.7 pg WHO-TEQ/g fat for dioxins/furans and 6.6 pg WHO-TEQ/g fat for dioxins/furans and dioxin-like PCBs combined; further investigations with this particular producer suggested the levels found might be attributable to the older age of the birds.

Market Food

The study was carried out on 65 samples of various foods available on the Irish market. Samples were obtained from producers (cereals, fruit and vegetables), from retail outlets (dairy products, oils/fats and soup) and from meat processors (carcass fat and liver) (Table 6.6). In the latter two cases, each sample for analysis was a composite of individual samples, ranging from 3 to 40 incremental samples per composite sample. The purpose of the study was to assess the exposure of consumers of Irish food to these biopersistent environmental contaminants known to be present in a number of foodstuffs, notably meat, fish, eggs and dairy products. The samples of market foods were tested for dioxins and PCBs in the specialist laboratory CSL, York, UK.

The results of the analyses for dioxins and dioxin-like PCBs are shown in Table 6.7. No measurable dioxins or dioxin-like PCBs were determined in cereals, fruit or vegetables. Only low levels of dioxins and dioxin-like PCBs were determined in samples of vegetable oils and



Table 6.6 Samples of market foods analysed for dioxins and dioxin-like PCBs

Food category	Origin	Food	No. of samples	No. of incremental samples/sample
Oils and fats	Retail	Animal/Vegetable fat	1	6
		Vegetable oil	2	3
Dairy products	Retail	Cheddar cheese	1	10
		Soft cheese	1	10
		Processed cheese	1	8
		Butter	1	10
		Dairy spread	1	10
		Yogurt	1	4
Soup	Retail	Packet soup	1	3
Vegetables	Producer	Potatoes	1	1
		Cabbage	1	1
		Carrots	1	1
		Lettuce	1	1
		Mushrooms	1	1
		Tomatoes	1	1
		Onions	1	1
		Peppers	1	1
Fruit	Producer	Strawberries	1	1
		Raspberries	1	1
		Apples	1	1
Cereals	Producer	Wheat, Barley, Oats	3	1
Carcass fat	Meat processor	Bovine fat	10	10
		Avian fat	8	10
		Ovine fat	8	10
		Porcine fat	8	10
Liver	Meat processor	Bovine liver	1	10
		Avian liver	4	40
		Ovine liver	1	10
		Porcine liver	1	10

Table 6.7 Dioxins and dioxin-like PCBs in market foods (pg WHO-TEQ/g^a)

Food	Number of samples	Mean		Minimum		Maximum	
		Dioxins	PCBs	Dioxins	PCBs	Dioxins	PCBs
Cereals	3	0.03 ^b	0.03 ^b				
Fruit	3	0.03 ^b	0.03 ^b				
Vegetables	8	0.03 ^b	0.03 ^b				
Fats	1	0.24	0.21				
Oils	2	0.05	0.05				
Carcass fat	34	0.27	0.26	0.08	0.05	0.62	0.61
Dairy products	6	0.19	0.18	0.08	0.05	0.25	0.27
Liver	7	1.19	0.42	0.32	0.11	4.04	1.42
Soup	1	0.12	0.07				

^a For cereals, fruit, vegetables, fats and oils, values are expressed as pg WHO-TEQ/g whole weight; for carcass fat, dairy products, liver and soup, values are expressed as pg WHO-TEQ/g fat.

^b No values determined above the limit of detection for the method (0.03 pg WHO-TEQ/g whole weight).

soup. The levels of dioxins and dioxin-like PCBs determined in dairy products were much below the maximum levels specified for milk and milk products in EU regulations; the highest levels determined were 0.25 and 0.52 pg WHO-TEQ/g fat for dioxins and for dioxins combined with dioxin-like PCBs, compared with maximum levels of 3 and 6 pg WHO-TEQ/g fat, respectively. In the case of carcass fat, all levels of dioxins and dioxin-like PCBs determined were at less than 30% of the maximum levels specified for the various meat species in EU regulations. Highest levels of dioxins and dioxin-like PCBs were determined in liver samples but these were at less than 30% of the maximum levels specified in EU regulations except for the one sample of ovine liver. This sample contained 4.04 and 5.46 pg WHO-TEQ/g fat for dioxins and for dioxins combined with dioxin-like PCBs, respectively. These values represent 67% and 46%, respectively, of the maximum levels specified in EU regulations for dioxins (6 pg WHO-TEQ/g fat) and dioxins combined with dioxin-like PCBs (12 pg WHO-TEQ/g fat).

Overall, these results indicate that the levels of dioxins and dioxin-like PCBs in Irish food products are relatively low compared with the maximum levels specified in EU regulations.

Reports

Results of the studies on dioxins, dioxin-like PCBs and brominated flame retardants by the FSAI are published and reports are available online on the Food Safety Authority of Ireland's website (www.fsai.ie).

Food Safety Authority of Ireland. 2002. Investigation on PCDDs/PCDFs and several PCBs in milk samples, FSAI, 47 pp.

Food Safety Authority of Ireland. 2002. Investigation on PCDDs/PCDFs and several PCBs in Fish Samples (Salmon and Trout), FSAI, 105 pp.

Food Safety Authority of Ireland. 2002. Investigation on PCDDs/PCDFs and several PCBs in Fish liver oil capsules, FSAI, 41 pp.

Food Safety Authority of Ireland. 2004. Investigation into Levels of Dioxins, Furans, PCBs and some elements in BATTERY, Free-Range, Barn and Organic Eggs, FSAI, 25 pp.

Food Safety Authority of Ireland. 2005. Investigation into levels of dioxins, furans, PCBs and PBDEs in Irish food 2004, FSAI, 26 pp.

Food Safety Authority of Ireland. 2007. Investigation into levels of dioxins, furans, polychlorinated biphenyls and brominated flame retardants in fishery produce in Ireland, FSAI, 32 pp.

6.3 Polycyclic Aromatic Hydrocarbons in Food

6.3.1 Introduction

Polycyclic aromatic hydrocarbons (PAHs) are organic compounds containing a number of fused aromatic rings composed of carbon and hydrogen atoms. There are a very large number of individual PAHs that may be formed during incomplete combustion of organic matter or during industrial processes. Food can be contaminated by PAHs in the environment or by PAHs that are formed during food processing or cooking operations, such as drying and smoking or grilling, roasting and frying. A range of toxicological effects are associated with PAHs, particularly carcinogenicity and genotoxicity. The PAH benzo(a)pyrene may be used as a marker for the occurrence and effect of carcinogenic PAHs in food and maximum levels for benzo(a)pyrene have been set by Commission Regulation (EC) No. 1881/2006 for a range of foodstuffs. The EU Scientific Committee on Food (SCF) has identified 15 PAHs (the SCF-15) that may be carcinogenic and genotoxic to humans and, because a Tolerable Daily Intake could not be set, has recommended that exposure to PAHs from food should be as low as is reasonably achievable.

6.3.2 Polycyclic Aromatic Hydrocarbons (PAHs) in Dairy Powders and Meat Products (Teagasc)

Two studies were undertaken for the Food Residue Database 1995-2000 on PAHs in dairy powders and in meat products. 50 samples of dairy powders from nine dairy companies were tested for PAHs during the period October 1996 to March 1997. The PAH contents of the samples, expressed as



Table 6.8 Ranges of levels of PAHs determined in categories of food samples ($\mu\text{g}/\text{kg}$ wet weight)

Food Category	Number of samples	Maximum level set for benzo(a)pyrene	Benzo(a)pyrene content	Sum SCF-15 PAHs	Sum 28 PAHs
Chocolate	18	-	0.06 – 0.30	1.13 – 3.87	4.2 – 32.5
Dried fruit	11	-	0.02 – 0.08	0.54 – 1.86	1.9 – 8.9
Fats/Oils	10	2.0	0.08 – 0.72	1.38 – 8.00	3.7 – 21.7
Infant food	10	1.0	0.0 – 0.15	0.51 – 1.12	1.0 – 7.4
Smoked meats	25	5.0	0.02 – 0.07	0.52 – 1.02	1.3 – 35.8
Fish/fish products	22	2.0 – 5.0	0.02 – 0.67	0.54 – 14.1	1.3 – 100.3
Dietary supplements ^(a)	24; 20 4	-	0.0 – 1.71 4.4; 5.2; 20.3; 66.7	0.82 – 24.2 76.6; 75.1; 276.2; 558.5	4.8 – 214.2 466; 487; 667; 1649

^aData for four dietary supplement products containing highest levels of PAHs are displayed separately

benzo(a)pyrene equivalents, were within the range of 0 to 0.6 $\mu\text{g}/\text{kg}$ (ppb). For the second study, pork and beef fat samples were obtained from 13 meat processing companies during the period September 1998 to June 1999 and samples of cured/smoked meat products from three companies were obtained during May 2000. No samples of meat fat or of cured/smoked products contained benzo(a)pyrene at levels above 0.1 $\mu\text{g}/\text{kg}$. The results for these studies show that the levels of benzo(a)pyrene determined were well below the maximum levels of 2 to 5 $\mu\text{g}/\text{kg}$ set for these food products by EC regulation.

6.3.3 Polycyclic Aromatic Hydrocarbons (PAHs) in Food on the Irish Market (FSAI)

A surveillance study was carried out by the FSAI in 2006 on the levels of PAHs in a variety of foodstuffs. The study was undertaken against the background of increased awareness of the possible health risks posed by PAHs in food and as part of Ireland's participation in investigating the levels of PAHs in certain foods, according to Commission Recommendation 2005/108/EC.

Samples

120 samples of food were purchased in different retail outlets located in Dublin, as follows: chocolate and chocolate biscuits

(18); dried fruit (11); fats/oils (10); fish and fish products (22); infant food (10); smoked meats (25); dietary supplements (24). The majority of samples were comprised of a number of sub-samples

Analysis

Samples were analysed for 28 PAH congeners, including the SCF-15 PAHs, by the Central Science Laboratory, York, UK using an accredited method with determination by high resolution gas chromatography coupled with low resolution mass spectrometry (HRGC-LRMS). Results are expressed as upper-bound levels (i.e. where the result for an individual congener is below the limit of detection, a value equivalent to the limit of detection is allocated), so the results reported are likely to be an over-estimation of the true occurrence.

Results

The most frequent PAHs occurring in the samples were chrysene, fluoranthene, pyrene, phenanthrene, benz(a)anthracene, benzo(ghi)fluoranthene and anthracene, occurring at measurable levels in more than 80% of samples tested. The ranges of values for benzo(a)pyrene, for the sum of the SCF-15 PAH congeners, and for the sum of the 28 PAH congeners are shown in Table 6.8. Very low levels were determined in infant food and dried fruit samples and relatively low levels were determined in smoked meats, chocolate, fats/oils and fish/



fish products samples. In no cases were the levels of benzo(a)pyrene determined in these food samples higher than 1 µg/kg, the lowest maximum level specified in regulations. In the case of dietary supplements, 20 (of 24) samples contained benzo(a)pyrene at less than 2 µg/kg and the other four samples contained benzo(a)pyrene at 4.4 to 66.7 µg/kg, with corresponding high levels for SCF-15 PAH congeners and for the 28 PAH congeners. No maximum levels for benzo(a)pyrene in dietary supplements have been set. The highest levels of PAHs in dietary supplements were in a sample of a bee product and a sample of green tea. The FSAI contacted the manufacturers/suppliers of dietary supplements containing high levels of PAHs with a view to reducing the levels found in these products.

6.4 Nitrate in Vegetables

Nitrate at excessive levels in leafy vegetables is a particular problem in many European countries including Ireland. Use of nitrogen fertilizers in farming is the likely source of much of the excessive levels in vegetables. Maximum levels have been set for nitrate in lettuce, spinach and foods for infants and children [Commission Regulation 1881/2006].

6.4.1 Nitrate Levels in Leafy Vegetables (DAFF)

There is a concern that human intake of nitrate is excessive; therefore, EU states are required to monitor nitrate levels in Lettuce and Spinach and report the results to the European Commission. The Department of Agriculture, Fisheries and Food provides samples of Lettuce and Spinach on a yearly basis, for analysis by the State Laboratory. Sampling and analysis for nitrate in Lettuce and Spinach is undertaken according to Commission Regulation 1882/2006/EC. The maximum levels applying to nitrate in Lettuce and Spinach according to Commission Regulation 1881/2006 vary depending on (a) the time of year when harvested and (b) the growing conditions applying.

Samples and Analysis

For each year's monitoring programme samples of lettuce and spinach (cabbage, also, in 2006) were taken from producers by Department of Agriculture, Fisheries and Food

inspectors. The total numbers of samples taken each year were between 69 and 115, with lettuce samples being between 46 and 87 and spinach samples being between 18 and 30; 11 samples of cabbage were taken in 2006. The samples were analysed for nitrate content at the State Laboratory using high performance liquid chromatography.

Results

The levels of nitrate determined in lettuce and spinach are compared with the maximum levels specified in Commission Regulation 1881/2006. Maximum levels set by this regulation vary depending on the period of the year when the crop is harvested (spinach and lettuce) and, in the case of lettuce only, whether the crop is grown under cover or in the open air; in the case of iceberg-type lettuce, lower maximum levels are specified (Table 6.9). Currently, maximum levels for other vegetables, such as cabbage, are not specified. The total numbers of samples of lettuce and spinach sampled in each year and

Table 6.9 Maximum levels set for Nitrate in foodstuffs (Commission Regulation 1881/2006)

Foodstuff	Maximum level (mg Nitrate/kg)	
Fresh spinach	Harvested 1 October to 31 March	3,000
	Harvested 1 April to 30 September	2,500
Preserved, deep-frozen or frozen spinach		2,000
Fresh lettuce	Harvested 1 October to 31 March:	4,500
	Lettuce grown under cover	4,000
	Lettuce grown in the open air	3,500
	Harvested 1 April to 30 September:	2,500
	Lettuce grown under cover	2,500
	Lettuce grown in the open air	
Iceberg-type lettuce	Lettuce grown under cover	2,500
	Lettuce grown in the open air	2,000
Foods for infants and young children		200

Table 6.10 Nitrate in Root and Leafy Vegetables, 2005-2006 (PALs Study)

Year	Commodity	Number of samples	Detected, No Limit	Detected, < Limit	Detected, > Limit
2005	Potatoes and Root vegetable	92	92		
	Leaf/Stalk vegetables	61		60	1
	Brassicas	73	73		
	Fruiting and other vegetables	14	14		
2006	Potatoes and Root vegetables	59	59		
	Leaf/Stalk vegetables	55		51	4
	Brassicas	36	36		
	Fruiting and other vegetables	10	10		

the number of these samples containing nitrate at levels above the appropriate maximum levels are shown in Figure 6.8. Samples containing nitrate at levels above the maximum vary between 0% and 13% for lettuce and between 17% and 48% for spinach over the six years of the monitoring programme. The numbers of samples containing nitrate at levels above the maximum levels are relatively evenly distributed between the two harvesting periods – October to March and April to September – over the six year period of the monitoring programme.

6.4.2 Nitrate Levels in Root and Leafy Vegetables, 2005-2006 (PALs)

The Public Analyst's Laboratories are responsible, inter alia, for surveillance of food for chemical contaminants. This network of laboratories comprises of three regional Public Analyst's Laboratories (PALs), located in Cork, Dublin and Galway. The laboratories analyse samples taken during official controls by Environmental Health Officers (EHOs). In the case of samples of root and leafy vegetables tested for nitrate, these samples are taken as part of a monitoring programme on nitrate in consumer foods.

Samples and Analysis

As part of a programme to monitor the nitrate levels in root and leafy vegetables, samples of vegetables and vegetable products were taken

from retail outlets and some from wholesale and catering establishments by Environmental Health Officers during 2005 and 2006. The samples were submitted to the Public Analyst's Laboratories in Cork, Dublin and Galway, as appropriate, for testing. Analysis for nitrate was by spectrophotometry or by chromatography.

Results

240 samples (2005) and 160 samples (2006) were taken for analysis, comprising mainly potatoes and root vegetables (carrot, turnip, parsnip), leaf/stalk vegetables (lettuce, spinach, celery) and brassicas (cabbage, broccoli, cauliflower). The ranges of levels of nitrate determined in the various vegetables in each year are shown in Table 6.10. Maximum levels are specified only for lettuce and spinach; in 2005, one sample of lettuce exceeded the relevant maximum level (2500 mg/kg); in 2006, three samples of lettuce exceeded the relevant maximum levels (2500 mg/kg, 2 samples; 4000 mg/kg, 1 sample) and one sample of spinach exceeded the relevant maximum level (3000 mg/kg).

6.5 Aflatoxins in Nut products

Aflatoxins at excessive levels in nut products is a problem in many European countries including Ireland. Aflatoxins are defined by four different variants – aflatoxin B1, aflatoxin B2, aflatoxin G1 and aflatoxin G2. Aflatoxin B1 is the most toxic of these variants. Aflatoxins are generated by storage moulds under warm and moist conditions. Food types typically affected include corn, peanuts and nut-based products. Maximum levels have been set for aflatoxins in nut products for human consumption [Commission Regulation 1881/2006].

6.5.1 Aflatoxin Levels in Nut Products, 2007 (PALs)

The Public Analyst's Laboratories are responsible, inter alia, for surveillance of food for chemical contaminants. This network of laboratories comprises of three regional Public Analyst's Laboratories (PALs), located in Cork, Dublin and Galway. The laboratories analyse samples taken during official controls by Environmental Health Officers (EHOs). In the

Table 6.11 Aflatoxins in Nut Products and other Commodities, 2007 (PALs Study).

Year	Commodity	Number of samples	Detected, No Limit	Detected, < Limit	Detected, > Limit
2007	Peanut Butter	95	285	176	14
	Corn, popcorn	1	3	2	0
	Mixed Cereals	1	3	2	0
	Chocolate	1	3	2	0
	Chocolate Spread	3	9	6	0
	Currant	4	12	8	0
	Date	5	15	10	0
	Dried Apricot	1	3	2	0
	Dried Fruit	2	6	4	0
	Fig	6	18	11	0
	Mixed Fruit	4	12	8	0
	Prunes	2	6	4	0
	Raisins (Dried)	13	39	26	0
	Sultanas	15	45	30	0
	Apricot	1	3	2	0
	Herbs & Spices	12	36	24	0
	Almond	25	75	46	4
	Almond Paste	1	3	2	0
	Brazil Nuts	3	9	6	0
	Cashewnut	12	36	24	0
	Cashewnut products	1	3	2	0
	Chocolate Nut Spread	3	9	6	0
	Ground Almonds	1	3	2	0
	Hazelnut	11	33	21	1
	Hazelnut Spread	23	69	46	0
	Marzipan	5	15	10	0
	Mixed Fruit and Nuts	5	15	10	0
	Mixed Nuts	5	15	10	0
	Nut Bars	2	6	4	0
	Nuts	58	174	112	4
	Peanut	47	141	94	0
	Pecan	3	9	6	0
	Pine Nuts	3	9	6	0
	Pistachio Nut	12	36	24	0
	Roasted Cashews	1	3	2	0
	Roasted Peanuts	8	24	16	0
	Salted cashews	6	18	12	0
	Salted Nuts	1	3	2	0
	Salted Peanuts	13	39	26	0
	Salted Pistachio Nuts	1	2	2	0
	Walnuts	7	21	14	0
Potato Crisps	1	3	2	0	
Vegetable Stock	1	3	2	0	

case of samples of nut products tested for aflatoxins, these samples are taken as part of a monitoring programme on aflatoxins in consumer foods.

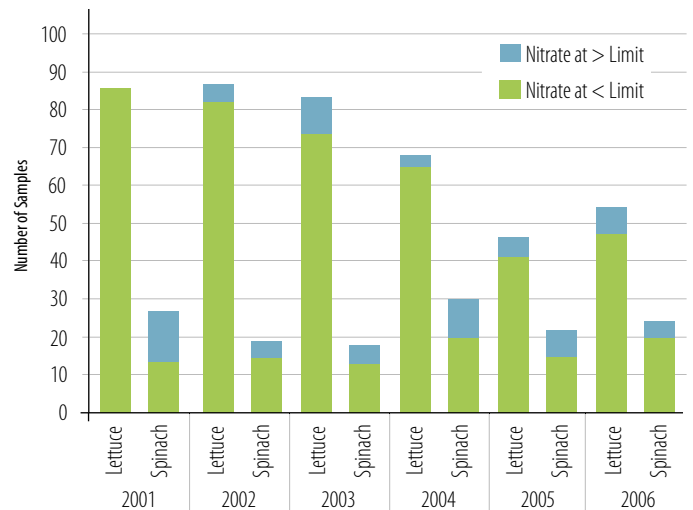
Samples and Analysis

As part of a programme to monitor the aflatoxin levels in nut products, samples of nuts and nut products were taken from retail outlets and some from wholesale and catering establishments by Environmental Health Officers during 2005 and 2006. The samples were submitted to the Public Analyst’s Laboratories in Cork, Dublin and Galway, as appropriate, for analysis by high performance liquid chromatography.

Results

425 samples were taken for analysis, comprising mainly peanut butter and nuts, raisins and condiments such as paprika, black pepper and curry. Each sample was tested for the four individual aflatoxins, as well as the sum of the four, giving a total of 2125 test results. The incidences of aflatoxin residues in the various matrices are shown in Table 6.11. Fourteen samples exceeded the limit for aflatoxin B1 (2.0 µg/kg), up to a maximum of 92.13 µg/kg. Nine exceeded the limit for the sum of the aflatoxins (4.0 µg/kg), up to a maximum of 113.67 µg/kg.

Figure 6.8 Nitrate in Lettuce and Spinach 2001 to 2006 (DAFF Study)



Glossary of Terms

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Acceptable Daily Intake (ADI)

The ADI of a substance is the amount of a residue in food that can be ingested daily over a lifetime without appreciable risk to the health of the consumer. The ADI is expressed in milligrams of the substance per kilogram body weight. The ADI value is derived from the toxicological data for the substance and is based on the No Observed Adverse Effect Level (NOAEL) in the most sensitive animal species used in toxicological studies. A safety factor to account for inter-species and inter-individual variation is applied and, in this way, the particular vulnerability of infants, children, the elderly and those whose systems are under stress because of ill-health are taken into account.

Action Level (or Action Limit)

The Action Level for a substance is the concentration of residue in food that results in action being taken. Where a Maximum Residue Limit (MRL) or a Maximum Level (ML) has been established for the chemical, the MRL or ML is the Action Level. Where no MRL or ML has been set, the Limit of Quantification (LOQ) may be used as the Action Level. In the case of prohibited substances or non-approved substances, any confirmed residue will be reported as in excess of the Action Level; in certain cases, the Minimum Required Performance Limit (MRPL) may be the Action Level.

Acute Reference Dose (ARfD)

The ARfD for a substance is similar to the ADI but it relates to intake of residue at one meal or on one day. The ARfD is expressed in milligrams of the substance per kilogram body weight. The ARfD value is derived from the toxicological data for the substance and is based on the No Observed Adverse Effect Level (NOAEL) in the most sensitive animal species used in toxicological studies that

are most relevant to short term exposure. A safety factor to account for inter-species and inter-individual variation is applied and, in this way, the particular vulnerability of infants, children, the elderly and those whose systems are under stress because of ill-health are taken into account.

Annex IV substances

Substances listed in Annex IV of Council regulation 2377/90/EEC are those substances for which, on safety grounds, no MRL can be set. Substances in Annex IV may not be administered to food-producing animals.

Good Agricultural Practice (GAP)

GAP refers to the appropriate use of plant protection products (pesticides) according to the authorised use, in terms of dosages, applications and withholding periods, to obtain adequate protection of the crop while leaving as little residue as possible in the crop.

Good Manufacturing Practice (GMP)

GMP refers to the processing of food in factories in such a way as to protect the quality of the product.

Good Veterinary Practice (GVP)

GVP refers to the appropriate use of veterinary medicines, including feed additives, according to the authorised use, in terms of dosages, applications and withholding periods, to obtain adequate treatment of animals while leaving as little residue as possible in food produced from the animals.

KAP (Programme for the Quality of Agricultural Products)

The KAP Databank has been developed in The Netherlands as a collaboration between agribusiness and government to promote the quality and safety of agricultural products.

**Limit of Quantification (LOQ)
or Limit of Determination (LOD)**

The LOQ, or LOD, is the lowest concentration of a residue that can be identified and quantitatively measured in a food sample using an analytical method that has been validated with specified accuracy and precision.

Maximum Level (ML)

An ML is the range of concentration of a substance from zero to a maximum level, expressed in milligrams per kilogram (parts per million, ppm) or in micrograms per kilogram (parts per billion, ppb), that is legally permitted in a food commodity. An ML is typically applied to contaminants and is established for particular food commodities such that potential consumer exposure to residues is judged to be tolerable.

Maximum Residue Limit (MRL)

An MRL is the maximum concentration of a substance, expressed in milligrams per kilogram (parts per million, ppm) or in micrograms per kilogram (parts per billion, ppb), that is legally permitted in a food commodity. An MRL is typically applied to a veterinary drug or a pesticide and is established for particular food commodities such that potential consumer exposure to residues is judged to be toxicologically acceptable. The MRL set for a substance may differ for different food commodities, reflecting the contribution of the particular food to a "standard" diet. Normal intake of food containing residue of a substance at its MRL is not expected to result in the ADI being exceeded.

**Minimum Required
Performance Limit (MRPL)**

An MRPL is set by the European Commission as that concentration of residue of a banned substance that an analytical method must be able to determine, with specified degrees of accuracy and precision.

No Observed Adverse Effect Level (NOAEL)

The NOAEL is the highest level of a substance to which test animals are exposed on an ongoing basis that causes no significant adverse toxicological effects.

Non-Compliant (or Positive) Sample

A non-compliant, or positive, sample is one for which confirmatory analysis has shown the presence of a prohibited or non-approved substance or, in the case of permitted substances and contaminants, a concentration above the MRL, ML or Action Level.

**Rapid Alert System for
Food and Feed (RASFF)**

The RASFF is a system adopted within the European Union whereby Member States are alerted when a residue of potential concern has been detected in food of domestic or imported origin.

Appendix

HOW TO SEARCH THE DATABASE

Introduction

The primary function of the NFRD is to display data that is available for specific residues in foods. If data is accessible, the information that may be obtained from the NFRD includes the study to which the data belongs, the laboratory that carried out the analysis, the analytical method used and the test results generated.

Table 1. Categorisation of Studies in the NFRD

Study Type	Definition	Examples
Monitoring Programmes	The Monitoring Programmes category contains any studies carried out on an annual basis in accordance with the requirements of National and European legislation.	<ul style="list-style-type: none"> Pesticide Residues in Food, 2005 (Pesticide Control Service) Residue Testing Plan for Ireland, 2007 (DAFF) Radioactivity Monitoring of the Irish Marine Environment, 2006 (RPII)
Residue Studies and Surveys	The Residue Studies and Surveys category contains individual studies carried out by agencies to establish if particular residues are present in foods.	<ul style="list-style-type: none"> Dioxin levels in the Irish Environment: Fourth Assessment (Summer 2006) - based on levels in cows' milk (EPA) Polycyclic Aromatic Hydrocarbons (PAHs) in Food on the Irish Market, 2006 (FSAI)

When a user submits a search to the NFRD an array of data is produced. The complexity of the data depends on the search parameters entered. In general the results returned for any given search will provide the user with a series of options. These include a list of

Studies where analysis was carried out, a list of Foods that were analysed for a residue or residue class, and a list of Residues that were tested for in a food or a food class. For each possible scenario, the test result information is displayed, along with a summary of the results found in the associated study, and background information to help interpret the data.

Carrying out a Search

When users open the NFRD website (<http://nfrd.teagasc.ie>), they can search for results within the database by selecting *Search Residue Database* on the left panel. On the *Main Search Criteria Page*, they are presented with four search criteria options: *Study Year*, *Study Type*, *Food* and *Residue* (Figure 1). Under *Study Year*, the website allows searching for one year or for any combination of years for which data are entered in the NFRD. Under *Study Type*, the user may select the type of study (Table 1) – either *Monitoring Programmes* or *Residue Studies and Surveys*; on the right side of the drop-down menu a link gives access to an introduction for the different types of studies. Under *Food Category*, the user may select a *Food Category*, a *Food Sub Category* or a specific *Food*; specific foods are directly accessible by using the *Help Me Pick a Food* button which allows selection of foods from alphabetical lists. Similarly, under *Residue Category*, the user may select a *Residue Category*, a *Residue Sub Category* or a specific *Residue*, again from alphabetical lists for specific residues using the *Help Me Pick a Residue* button.

Interpreting the Results

Search Results Summary Table

The search results are displayed in table format. The first table generated is the *Search Results Summary Table* (Figure 2). Typically this provides an overview of results by the number of studies, test results, foods, residues and sample country of origin that comply with the specified search criteria.

An advanced search facility is available at this point, which allows the user refine their search further by filtering any unwanted results from the summary table. The filter options include:

Figure 1. Main Search Criteria Page

- *Apply Residue Found Filter:* The majority of test results in the database show no residue detected. By applying the found filter the user may view only those test results in which a residue was found.
- *Apply Country Filter:* Where the samples analysed originated from a number of different countries, the user may select a country so as to only view results for the selected country.
- *Apply Study Filter:* Where the results come from more than one study, the user may select a single study so that only results from the selected study are displayed.

Accessing Test Result Information

From the *Search Results Summary Table* a more detailed breakdown of the results is accessible by selecting one of the following categories: *Study, Food, Residue, Country*.

On selecting *Study*, a list of the studies meeting the search criteria is presented. From here it is possible to view the *Study Details* for each study listed. On the *Study Details* page is a *Study Overview* – a summary of the entire information available in the database for a particular study. This includes a short introduction to the study, links to the background information relevant to interpret the data, and a summary of the entire test results generated from that study. The summary of test results is displayed in two tables, which are two different views of the same data. The first table generated displays all the foods tested in the study. Each row in this table contains the name of the food, the number of samples analysed and the results of analysis. The second table displays the residues tested, and for each residue the total number of samples analysed and a summary of the results of analysis.

On selecting *Foods, Residues* or *Country*, a summary

table of the individual foods, residues or countries is generated. From these tables the user may access more detailed information on the test results. For example, the *Foods Summary Table* displays the number of samples analysed for a particular food, as well as the number of test results obtained (Figure 3).

It is important to note that in any study a single food sample may be analysed for multiple residues. Each test result obtained for a food sample is individually recorded in the NFRD. Therefore a single test result consists of one food sample being analysed for one residue. In the situation where a particular food sample was tested for five residues, there will be five corresponding test results in the database.

From the *Foods Summary Table* it is possible to navigate through the website so that the entire set of test results and background information for an individual food item, for example *Orange*, may be accessed. This also applies to the *Residue* and *Country Summary Tables*. On selecting a specific food the format in which the test results data is displayed may differ according to the data source. This in turn affects how the data is interpreted. The variation in the presentation of data is dependent on the type of description used to indicate the presence of a residue in the test result. Four categories have been created to accommodate this:

- 1) Not Detected; Detected
- 2) Not Detected; Detected, < Limit;
Detected, > Limit; Detected, No Limit
- 3) Detected, < Limit;
Detected, > Limit; Detected, No Limit
- 4) Compliant; Non-Compliant

The reason for creating the above categories is that generally the interpretation of data on residues in food is made against residue limits set by regulatory bodies. However, for some residues in foods there

Figure 2. Search Results Summary Table

Search Results Summary Page

The table below shows a summary of your search results under various headings. Click the corresponding link in the details column to see a breakdown of your results for any particular heading.

Result	Amount	Details
Number of different studies in the results.	3	View
Total number of test results returned.	1358	View All
Number of test results of Irish origin.	1358	
Number of test results of non-Irish origin.	0	
Number of different countries of origin in the results.	1	
Number of different foods in the results.	5	View
Number of different residues in the results.	10	View

Figure 3. Foods Summary Table

Search Results - Foods Summary

[Return to Search Results Summary Page](#)

This pages shows a foods breakdown of the test results returned by your search.

Use the link in the Details column, if you want to view a **list of results for one food**.

Food Category	Food Sub Category	Food	Number of Samples	Number of Results	Details
Dairy Products	Milk	Acid Casein Powder	43	344	View Results
Dairy Products	Milk	Rennet Casein Powder	33	264	View Results
Dairy Products	Milk	Skim Milk Powder	71	568	View Results
Dairy Products	Milk	Whole Milk	32	32	View Results
Fish, Shellfish and Molluscs	Finfish - Oil-Rich Fish	Farmed Salmon	150	150	View Results

[Return to Search Results Summary Page](#)

are no set limits. As a result, test results generated from analysis of a residue in a food where there are no established limits are summarised as either *Not Detected* or *Detected*. Where the majority of residues in a study have residue limits the test results are summarised as *Not Detected; Detected, < Limit; Detected, > Limit; Detected, No Limit*. For some contaminants, such as dioxins/PCBs, there are calculated values for all the tested samples; in these cases the test results are summarized as *Detected, < Limit; Detected, > Limit; Detected, No Limit*. Finally, in some cases the result of a residue analysis has been recorded as *Compliant* or *Non-Compliant*. Here the *Compliant* samples meet the requirements of the residue limits but no distinction is made between samples where a residue was not detected and samples where a residue was detected but at

a level below the residue limit. Table 2 gives definitions for each of these categorisations.

Additional Features for Results

Significant features have been added to enhance the analysis of results from searches on the NFRD. The *Study Overview* page summarises numbers and percentage values for non-compliant samples in a study. It also gives information about the non-compliant food types and residues. For studies that are repeated each year, such as, for example, monitoring programmes, the user has access from the *Study Overview* page to the *Repeating Study Summary* page. On this page, a graph presents the ratio of compliant/non-compliant samples within the series of studies. Additionally, a list with key results for each study in the group is provided on this page. This overview includes, for each year's study, the number of test results, number of samples tested, and number and percentage of non-compliant samples. The non-compliant samples, as well as the residues that were found to be above the limits, are listed.

Accessing Additional Information

Features incorporated into the website that assist the user in the interpretation of the chemical residue data for food include a *Document Library*. From the *Search Document Library* button, the user may access available background information on residues, legislation and specifications relating to residues in food, as well as further links and a glossary of terms.

In addition the user has the option to supplement their search results by using the *Graph* function. This option to generate a chart or graph dynamically from the data is particularly helpful where a search has returned a large number of results.

Table 2. Data categorisations used for different studies in the NFRD

Category	Term	Definition
Compliant; Non-Compliant	Compliant	No residue detected in the sample (i.e. residue absent or below the limit of determination for the method) or Residue was determined in the sample, but at a concentration below the specified residue limit
	Non-Compliant	Residue was determined in the sample, at a concentration above the specified residue limit
Not Detected; Detected	Not Detected	No residue detected in the sample (i.e. residue absent or below the limit of determination for the method)
	Detected	Residue was determined in the sample, at a concentration above the limit of determination for the method
Not Detected; Detected, < Limit; Detected, > Limit; Detected, No Limit	Not Detected	No residue detected in the sample (i.e. residue absent or below the limit of determination for the method)
	Detected, < Limit	Residue was determined in the sample, but at a concentration below the specified residue limit
	Detected, > Limit	Residue was determined in the sample, at a concentration above the specified residue limit
	Detected, No Limit	Residue was determined in the sample, at a concentration above the limit of determination for the method, but there is no residue limit specified for the particular residue in that sample type