SAFETY OF CHEMICALS IN FOOD
Chemical Contaminants

Editor:
D. H. WATSON
Ministry of Agriculture, Fisheries and Food, London

ELLIS HORWOOD
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SAFETY OF CHEMICALS IN FOOD
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Preface

Although there are many books that review particular groups of chemical contaminants in food in great depth, there is no general guide that can help introduce food scientists, and others, to this important area of work. There is also much media coverage, some of it inaccurate, but there is not a general source of reference on the extensive but still developing subject of chemical contaminants in food. The purpose of writing this book is to give a general introduction to the main groups of these chemicals—to provide the reader with information about which chemicals are involved, why they contaminate food and how their impact on the food chain can be measured. The major groups of chemical contaminants are reviewed in Chapters 2 to 8. There is not a chapter on radioactive elements since scientific work on these substances is quite distinct—it is the contamination of food with radioactivity that is of primary interest whereas for other chemical contaminants it is the chemicals themselves that are mainly studied.

This book goes into some detail about the methodology used in scientific work on chemical contaminants in food. Methods of analysing food have been reviewed elsewhere (see for example *Analysis of food contaminants* edited by Dr John Gilbert, publ. Elsevier Applied Science, 1984), but the general principles and approaches of analytical work are summarized here where it is essential for a proper understanding of work on the chemicals. There is less information, and little guidance, in the literature about how food chemical surveillance is carried out, or on the fundamentals of estimating consumers' intakes of chemical contaminants. These two key areas of methodology are therefore described and reviewed in detail, in Chapters 9 and 10.

The study of chemical contaminants in food is still a relatively young science. Some key areas are in particular need of further work—these are reviewed in Chapter 11. It is hoped that the reader will be stimulated by this chapter, and the rest of the book, to find out more about chemical contamination of food. To help in this, references to the literature have been chosen not for the usual reason of providing experimental detail but to expand upon and illustrate further some of the main points. There is also a part of Chapter 9 (section 9.8) which introduces the reader to the extensive range of research journals and other sources of experimental information on surveillance for chemical contaminants in food.

This book should serve as a useful introduction to those with a professional interest in food safety, as well as those who have to learn about chemical contamination as part of their formal education. It provides considerable data and information, as well as insights into the thinking of scientists who work on chemical contamination in food. The opinions stated are those of the authors—they are not official statements of the organization for which the authors work. Much of the illustrative data and information are drawn from scientific work by the Government in the UK because its programme of work is extensive and generally at the forefront of this scientific subject. And the findings of UK work have been confirmed in other countries. But reference is made to work in other parts of the world to provide an international picture.

Last, but not least, I am happy to acknowledge the efforts of many colleagues over the years to help establish chemical contamination of food as a scientific subject, and I am also pleased to recognize the advice and constructive comments of Dr Richard Burt on the text of this book.

D. H. Watson
October 1992
R242, Ministry of Agriculture, Fisheries and Food,
Ergon House,
c/o Nobel House,
17 Smith Square,
London SW1P 3JR, UK.

Glossary of terms and abbreviations

ACP: Advisory Committee on Pesticides (see Fig. 9.2).

Acute toxicity: Toxicity that occurs soon after exposure to the toxic substance (within hours or a few days).

ADI: Acceptable Daily Intake. The amount of a chemical which can be consumed every day for an individual's entire lifetime in the practical certainty, on the basis of all the known facts, that no harm will result. The ADI is expressed as milligrams of the chemical per kilogram bodyweight of the consumer.

AQA: Analytical quality assurance.

CCRVDF: Codex Committee on Residues of Veterinary Drugs in Foods.

Carcinogen: A substance that causes cancer.

Chronic toxicity: Toxicity that occurs a considerable time after exposure to a toxic substance (usually months or longer).

Concentration (= level) of a chemical contaminant in food or drink: The amount of the chemical contaminant per unit weight of food or drink. Several different units are used:

mg/kg (equivalent to one part per 10^6) ng/kg (equivalent to one part per 10^{12})
μg/kg (equivalent to one part per 10^9) pg/kg (equivalent to one part per 10^{15}).

CVMP: EC Committee for Veterinary Medicinal Products.

EC: European Community.

FAO: Food and Agriculture Organization (of the United Nations).

FSIS: US Food Safety and Inspection Service.

GC: Gas chromatography.

HCB: Hexachlorobenzene.

HCH: Hexachlorocyclohexane.

HPLC: High performance (or high pressure) liquid chromatography.

Limit of detection: The lowest concentration of a chemical contaminant that can be identified and quantitatively measured in a specified food or drink, or raw material used in their production, with an acceptable degree of certainty by a given method of analysis.

MAFF: Ministry of Agriculture, Fisheries and Food (a UK Government department).

MRL: Maximum Residue Limit (for residues of pesticides and veterinary drugs in food). A definition for MRL as applied to work on veterinary residues is given in Chapter 2, section 2.2.4.1. A definition for MRL as applied to work on pesticides residues is as follows: the maximum concentration of pesticides residues likely to occur in or on a food commodity, either resulting from the use of the pesticide according to good agricultural practice (directly or indirectly for the production and/or protection of the commodity concerned) or arising from environmental sources, including former agricultural uses.

MS: Mass spectrometry.

Mycotoxins: Toxins produced by fungi.

NDMA: *N*-Nitrosodimethylamine.

NSS: UK State Veterinary Service's National Surveillance Scheme.

PCBs: Polychlorinated biphenyls.

PCDDs: Polychlorinated dibenzo-*p*-dioxins.

PCDFs: Polychlorinated dibenzofurans

SCF: Scientific Committee for Food (of the EC Commission).

SGCAFS: Steering Group on Chemical Aspects of Food Surveillance (see Fig. 9.2).

SI: Statutory Instrument (a type of legislation in the UK).

TDI: Tolerable Daily Intake (see ADI and p. 2).

TDS: UK Total Diet Study (see Chapter 10, section 10.4.2).

TEQ: Toxic equivalents.

VPC: Veterinary Products Committee (see Fig. 9.2, and Chapter 2, section 2.2.1).

WHO: World Health Organization (of the United Nations).

Table of contents

1

Introduction

D. H. Watson, Ministry of Agriculture, Fisheries and Food, R242, Ergon House, c/o Nobel House, 17 Smith Square, London SW1P 3JR, UK.

1.1 DEFINITION OF 'CHEMICAL CONTAMINANT'

The definition of a chemical contaminant used in this book is as follows:

> Any substance not intentionally added to food, which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food, or as a result of environmental contamination *or its production by a living organism*.

This is the definition used by the United Nations' Codex Committee on Food Additives and Contaminants, except for the last seven words in italics which are added here to include naturally occurring toxicants. Thus the definition covers all of the substances that are reviewed in this book. The chemicals can be classified into various categories according to why they are present in food (Table 1.1). It is worth noting that most chemical contaminants can arise from more than one activity. Indeed pesticides residues in food can result from nearly every activity listed in Table 1.1.

It should also be noted that 'food' in the above definition is generally taken to include drink by scientists who work on chemical contaminants. Both parts of the diet are included.

1.2 SCIENTIFIC WORK ON CHEMICAL CONTAMINANTS IN FOOD

The study of chemical contamination of food has developed as a scientific subject primarily over the last twenty years or so. Its relatively recent development has been due to a number of factors, of which the following are probably the main ones:

— Many methods of analysis have been developed which are suitable for detecting and quantifying the very low concentrations of chemicals in food. This has been part of a

Table 1.1. A classification of chemical contaminants in food

Activity	Related chemical contaminants that can occur in food
Crop production	Pesticides, nitrate, metals, naturally occurring toxicants
Animal production	Pesticides, veterinary drugs, metals
Food manufacture	Pesticides, metals, nitrate, nitrite, nitrosamines
Packaging of food	Chemicals migrating from packaging
Food storage	Pesticides, metals
Industrial	Environmental organic chemical contaminants (e.g. benzene), metals, pesticides

transfer of expertise and techniques from other areas of science to the study of food safety.

— The science of toxicology has developed rapidly making it possible to test the toxicity of a wide range of chemicals used by man, for example pesticides, veterinary drugs and industrial chemicals.

— It has been found that food can be chemically contaminated by several routes, from the use of agricultural and other chemicals.

— Growing public interest in food safety has been stimulated by media coverage of the results of some of this scientific work.

— An increasing variety of controls on chemical contamination of food has been introduced, both in individual countries and on international trade.

It is impossible to say which of these factors has been most important in stimulating the scientific work, but it is clear that the science has been allowed to develop quickly because of the development of analytical methods to detect chemical contaminants in food. This has been a key factor because it is the very low concentrations of chemical contaminants in food that distinguish them from most other forms of contamination of food. These concentrations are generally one milligram of chemical per kilogram of food (one part per million), or less. Levels of one part in 10^{14} are now detectable for some chemical contaminants in food (for example dioxins: Chapter 3). And it is essential that such extremely low concentrations can be detected because in many cases chemical contaminants occur only very rarely at greater concentrations in food. Not surprisingly it can be difficult to judge the toxicological significance of such low concentrations of chemicals in food. Nevertheless there has been considerable progress in identifying what the toxic effects might be, if any, and in deciding the maximum amounts of given chemical contaminants that can be consumed without risk to the consumer. The setting of tolerable daily intakes (TDIs) for chemical contaminants in food is becoming a key part of the study of these substances. In the past the term acceptable daily intake (ADI) was used but TDI is now preferred because exposure to chemical contaminants is tolerable rather than acceptable. These and other specialist terms used in this book are defined in the *Glossary of terms and abbreviations* at the front of the volume.