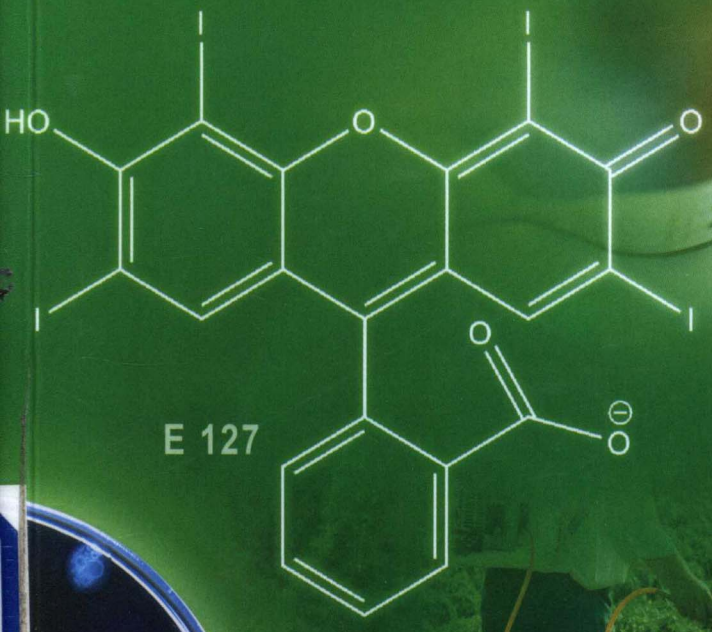
Food Safety

The Science of Keeping Food Safe

Ian C. Shaw



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Ian C. Shaw

Director of Biochemistry & Professor of Toxicology
University of Canterbury, Christchurch, New Zealand

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Food Safety

This book is dedicated to the memory of two lovely ladies:
My mother
Audrey Shaw
28 November 1928 to 28 May 2009

My mother-in-law
Jeanne Zehms
6 May 1919 to 5 December 2010

They both inspired me in their own special ways.

Preface

We expect our food to be safe; we certainly don't expect to be ill after eating a meal. However, it is important to remember that this is an affluent Western world expectation and that many undernourished people in the poorer parts of the world simply want to eat – the safety of their food is a secondary, or an even lesser, consideration.

Our desire for safe food, spurred on by food disasters like Mad Cow disease in the UK in the mid 1980s, has led to developed countries introducing legislation to ensure safe food – to make sure that food is fit for purpose.

In order to make food safe, we need to understand what makes it unsafe. Why do some microorganisms (pathogens) in food cause disease in their consumers, while others are harmless – or even beneficial? We need to minimise our exposure to food pathogens in order to minimise consumer risk. We need to understand why chemical food contaminants, like pesticides used in food production, can harm their consumers and we need to know the doses that are harmful so that we can set safe levels for chemical contaminants in food and so further minimise risk.

To store food we often use preservatives, otherwise harmful microorganisms might grow on the stored food; if we use chemical preservatives we must understand their potential toxicity to the consumer and make sure the chemical preservatives don't solve a microbiological problem, but introduce unacceptable chemical toxicity.

As consumers become more pernickety about their food they want it to look and taste exactly right – and by exactly right I mean how *they* think it should look and taste. To achieve this, colours and flavours are added to many pre-prepared foods. But are these additives safe? What are their effects on their consumers? Is using colours and flavours to enhance our food experience an acceptable risk?

Food is inextricably linked to health. If we eat too much fat or sugar we might become obese and our health will be significantly impacted – this might lead to heart disease or diabetes, both serious diseases. Some bacteria (e.g. Listeria) that might contaminate food cause serious diseases, even death. On the other hand, the contaminants and additives present in our food might affect our health in far more esoteric ways following very long-term exposure. For example, some food colours are known to cause cancer in rats at high doses, but what effects might they have on human consumers of infinitesimally tiny doses in food? Are these risks outweighed by the benefits of the chemicals? Is bright red cherryade worth the vanishingly low risk of its consumer contracting thyroid cancer? Do you *need* your cherryade to be bright red? Is any health risk associated with food colour acceptable – however small?

These are all fundamentally important questions – and there are many, many more – to which we should seek answers if we are to make our food safer. We need to understand the science that underpins food safety; we need to tease out the health effects of chemicals in our food and set these risks against their benefits. Is the risk of a bacterium growing in our food greater than the chemical used to kill it? Why is the chemical harmful to its consumer? Could we modify its molecule to make it less toxic, but maintain its bactericidal properties? These are some of the answers we might need to help us to produce and regulate our food and make it as fit for purpose as possible.

Over the last 50 or so years our understanding of food safety has grown to such an extent that we no longer accept food-borne illness as a consequence, albeit rare, of eating. Those responsible for food-borne illness outbreaks can fall foul of strict food legislation and find themselves subjected to heavy fines or, in rare cases, even imprisonment. Just 50 years ago this would not have been thought possible.

My book takes a trip through the world of food safety, from microbiological food pathogens, through chemical contaminants, natural toxins and the chemicals we use to colour, preserve and flavour our food. It grapples with the esoteric prion that causes Mad Cow disease which led to the collapse of the UK beef industry and prevents me as a Brit living in New Zealand from donating blood because of the perceived risk of transferring the prion to my fellow New Zealanders. It uncovers the controversy of 'organic' food and food irradiation. Finally, it looks at the laws that are used to make sure that when we eat our dinner or buy a snack on the street we don't contract a food-borne illness or expose ourselves to chemicals that might compromise our health in the future. This is a long journey flavoured with many examples from around the world; I hope you enjoy it!

Professor Ian C. Shaw PhD, FRSC, FIFST, FRCPath
Christchurch, New Zealand
September 2012

Acknowledgements

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As with any wide-ranging textbook, there are subjects included that the author is less *au fait* with; in my case food legislation was the subject that I needed expert help with. I thank Keith Zehms and Sharon McIlquham for their advice on US law and John Reeves for his help with the New Zealand food legislation.

When I agreed to write the book and signed the contract on 21 January 2010 I could not, in my worst nightmare, have anticipated the devastation that the 4 September 2010, 22 February and 13 June 2011 Canterbury (New Zealand) earthquakes would bring to my life and environment. Much of this book was written during a period of regular and significant aftershocks, telecommunication failures, lack of internet, uncertainty about the stability of buildings, workmen everywhere, continual battles with the New Zealand Earthquake Commission and our insurers, and deep, deep sadness for the loss of our city and some of its people. Throughout this, my partner, David Zehms, gave me unwavering support and provided some semblance of emotional normality that allowed me to retire to my cracked and crumpled study to write this book – thank you David.

As you read, think of the people of Christchurch and Lyttelton, New Zealand, who have lost so much and have a long, hard road ahead.

I hope you enjoy my book.

Ian C. Shaw
Christchurch, New Zealand

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A colour plate section falls between pages 52 and 53

Chapter 1
Introduction

Introduction

Food safety is a relatively recent 'invention'. It was introduced in the developed world to increase confidence in food. In our modern world it simply is not acceptable to have food that might make us ill. Sadly even now a good proportion of the world's people are very much more concerned about getting food and stemming their unrelenting hunger than they are about whether they might get a stomach upset as a result of eating the food. We must always remember these horrifying facts when we study food safety. Food safety and the legislation emanating from it are for the relatively rich countries that have the luxury of having sufficient food to allow them to make rules about what is safe to eat.

A brief history of food safety

Prehistoric times

The risk of eating in prehistoric times was very much more an issue of the dangers of catching the beast to eat than the ill effects suffered after eating it. To survive, cavemen had to eat and their animal instincts dominated their behaviour with respect to food. These instincts, no doubt, made them avoid food they had learned made them sick, but their overriding instinct was 'eat to live'. Some foods, however, might have been so toxic that they threatened the early man's survival. Behaviour that minimised consumption of toxic food would have been selected in because individuals that succumbed to toxins in their food simply did not survive. This is the raw material of Darwinian evolution and could be considered a very early manifestation of food safety issues! Whether this happened or not thousands of years ago is impossible to know, but we do know that modern-day animals avoid toxic plants in their diet. This might be because some of the toxins (e.g. alkaloids) have a bitter taste that warns the would-be consumer of the risk. Prehistoric man probably behaved in exactly this way which is why he was able to survive in such a harsh environment in which every day posed new and unknown food challenges.

Food Safety: The Science of Keeping Food Safe, First Edition. Ian C. Shaw.

This is hardly prehistoric food safety policy, but it illustrates our inborn survival instinct that extends to the food we eat. We have an innate desire not to eat something that will make us ill. This has not changed over the millennia.

Evolution of cellular protection mechanisms

It is important to remember too that our metabolic systems (and avoidance strategies) evolved during the tens of thousands of years of prehistoric times. Metabolism of toxins from food in order to reduce their toxicity and so make the food 'good' developed over millions of years. There are highly complex metabolic systems 'designed' to detoxify ingested toxins that evolved long before man, but the enzyme systems from the primitive cells

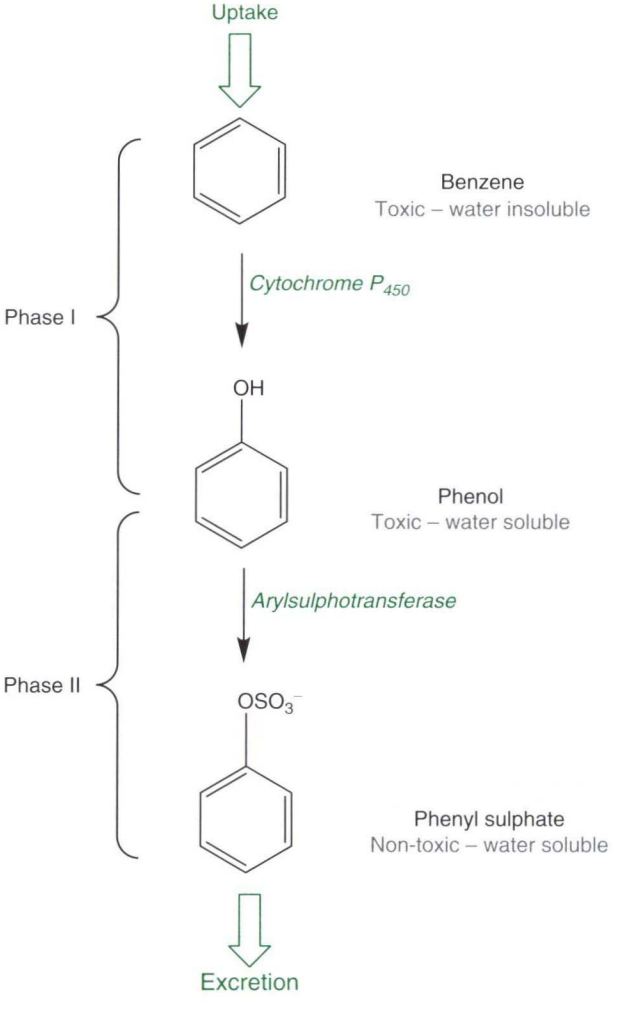

Figure 1.1 Phase I and II metabolism for a simple compound, benzene, showing how the molecule is detoxified, made water soluble and excreted (e.g. in urine).

in which they evolved were selected into the human genome through the evolutionary process and were inevitably expressed by the earliest hominids. These detoxification systems gave man an advantage because he could eat food that contained chemicals which if not detoxified would make the food too toxic to eat. These enzyme systems are now very well understood; they include the cytochromes P_{450} mixed function oxidases (termed Phase I metabolism) and the conjugating enzymes (termed Phase II metabolism) (Figure 1.1).

There are many food toxins that are detoxified by these systems, so making the food safe to eat (this will be discussed further in Chapters 7 and 8); for example, parsnips contain bergapten, a photosensitising toxin that also causes cancer (see Chapter 8, *Furocoumarins in parsnips, parsley and celery*); bergapten is detoxified by Phase I and II metabolism (Figure 1.2)

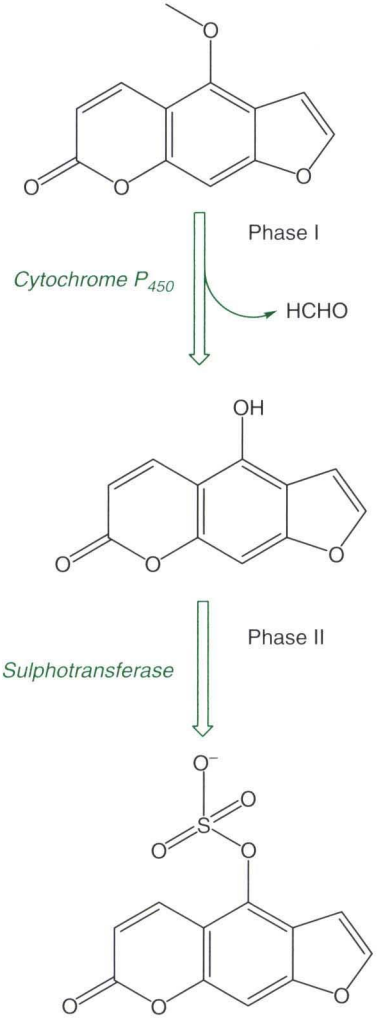

Figure 1.2 A proposed metabolic pathway for bergapten.

thus making parsnips safe to eat. These metabolic processes are the cell's internal food safety mechanisms and broaden the range of foods we can eat without suffering the ill effects that some of their components would cause.

There are significant differences in the susceptibility of different animal species to toxic chemicals; these are due to the evolutionary selective pressures under which the particular species developed. This means that safe foods for some species might be highly toxic to others. For example, the toxin in the swan plant (*Asclepias fruticosa*), labriformidin, is very toxic to birds but harmless to the monarch butterfly (*Danaus plexippus*) (see Chapter 8, *Why produce natural toxins?*).

The monarch butterfly uses this differential toxicity as a means of protection. Its caterpillar eats swan plant leaves and incorporates labriformidin into its body; this makes it toxic and unpalatable to predatory birds. This interesting means of survival is by no means unique amongst animals. Indeed, some plants that are eaten by animals are very toxic to humans. For example, it would only take a few leaves of hemlock (*Conium maculatum*) to kill a person, but the skylark (*Alauda arvensis*) is unaffected by its toxin (Figure 1.3). Indeed, there have been cases of human poisoning in Italy following consumption of skylarks which (strange as it may seem) are a delicacy in that country. The toxin in hemlock is coniine (Figure 1.3) – it is very toxic; about 200 mg would be fatal to a human. Hemlock was the poison used to execute Socrates in 399 BC for speaking his mind in the restrictive environment of ancient Greece.

Tudor England (1485–1603)

In the 1500s I doubt whether many people thought about illness being linked to what they had eaten, but I imagine food-borne illness was prevalent in that rather unhygienic society. In fact spices were introduced into Tudor England to mask the putrid taste of some foods particularly meat – this is a 'head in the sand' approach where masking the bad taste was thought to take away the bad effects. Whether the Tudors thought that masking the taste of putrefying meat stopped them getting ill I cannot know, but they certainly thought that masking the terrible smells of putrid plague-ridden London prevented them catching fatal diseases like the Plague. The gentry used, amongst other things, oranges stuck with cloves, and ornate necklaces with receptacles for sweet-smelling spices and resins (pomanders – derived from the French *pomme d'ambre* meaning apple of amber; ambergris, a sweet-smelling substance produced by sperm whales was often used to scent pomanders) to waft in front of them to take away the evil smells as they walked the streets. This is hardly food safety legislation, but it might just be the beginning of people connecting off-food with illness – a key step in making food safe.

The times of King George III of England (1760–1820)

The Georgian era was a time of great social division. The rich ate well, if not exuberantly, and the poor just about found enough food to keep them alive. The idea that bad smells were associated with disease prevailed as