CHAPTER 1

Introduction

For the chemists of the eighteenth and nineteenth centuries an understanding of the chemical nature of our food was a major objective. They realised that this knowledge was essential if dietary standards, and with them health and prosperity, were to improve. Inevitably it was the food components present in large amounts, the carbohydrates, fats, and proteins, that were the first nutrients to be described in chemical terms. However, it was also widely recognised that much of the food, and the drink, on sale to the general public was very likely to have been adulterated. The chemists of the day took the blame for some of this:

> *"There is in this city [London] a certain fraternity of chemical operators who work underground in holes, caverns and dark retirements ... They can squeeze Bordeaux from the sloe and draw champagne from an apple."*
>
> *The Tatler,* 1710.

However, by the nineteenth century the chemists had begun to expose some of the malpractices of food suppliers. In 1824 a local newspaper in the north of England reported on the chemical analysis of some confectionery:

> *"One pennyworth of red balls, called we believe, Nelson or Waterloo Balls, – there were no such fine names in our lick-finger days, – yielded on analysis 30 grains of an indissoluble matter resembling*

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red-lead, which on being fused with the blow-pipe produced 24 grains[i] *of lead in a metallic state.........*"

A quarter of a century later a famous survey was published[ii] that revealed the extent to which the confectioners routinely borrowed colourings from the palettes of the painters (of both pictures and houses). Lead chromate (yellow), lead oxide (red), Prussian Blue (a mixture nominally described as ferric ferrocyanide), copper oxychloride (green), copper arsenite (green) and mercuric sulfide, vermilion (scarlet), were all in common use as food colours.

Chemistry was being brought to bear not only on the detection of dangerous colourings in confectionery but also on unwelcome use of many other unexpected food ingredients. A major incentive for the development of chemical analysis of food and drink was financial. The British government's activities were largely funded by excise duties on alcohol and tea and large numbers of chemists were employed to protect this revenue from the effects of the dilution and adulteration of wines and spirits *etc.*

As physiologists and physicians began to relate their findings to the chemical knowledge of foodstuffs the need for reliable analytical techniques increased. Twentieth century laboratory techniques were essential for the study of vitamins and the other components that occur in similarly small amounts, including the natural and artificial colouring and flavouring compounds. Until the use of gas chromatography (GC) became widespread in the 1960s the classical techniques of "wet chemistry" were the rule, but since that time increasingly sophisticated instrumental techniques have taken over. The latest methods are now so sensitive that many food components can be detected and quantified at such low levels (parts per billion, *i.e.* 1 microgram per kilogram, are commonplace) that one can have serious doubts as to whether the presence of a particular pesticide residue, or environmental toxin, at the detection limits of the analysis can really have any biological or health significance. It is perhaps some consolation for the older generation of food chemists that some of the methods of proximate analysis[iii] that they, like the author, struggled with in the 1960s, are still in use today, albeit in automated apparatus rather than using extravagant examples of the glassblower's art.

[i] 24 grains = 1.55 g.

[ii] Hassall, A H, (1855) *Food and its Adulterations: comprising the Reports of the Analytical Sanitary Commission of 'The Lancet' for the years 1851 to 1854 inclusive.*

[iii] The determination of total fat, protein, carbohydrate, ash (as a measure of metals) and water.

By the middle years of the twentieth century it appeared that most of the questions being asked of food chemists by nutritionists, agriculturalists and others had been answered. This was certainly true as far as questions of the "What is this substance and how much is there?" variety were concerned. Chemists are nowadays expected to identify and quantify all the innumerable undesirable substances, both natural and man-made, which are to be found in our food. However, as reflected in this book, over the past few decades new questions have been asked and many of the answers are still awaited. The greatest challenge food chemists now face is to explain the *behaviour* of food components. What happens when food is processed, stored, cooked, chewed, digested and absorbed? Much of the stimulus for this type of enquiry has come from the food manufacturing industry. For example, for many of us the observation that the starch in a dessert product provides a certain amount of energy has been overtaken in importance by the need to know which type of starch will give just the right degree of thickening, and what is the molecular basis for the differences in behaviour between one starch and another. And, furthermore, that dessert product must have a long shelf life, look as pretty and taste nearly as good as the version served in an expensive restaurant.

Many of the changes in food materials during food processing, storage *etc.* are definitely chemical in nature, such as the reactions involved in caramelisation or rancidity. Other changes may involve less permanent types of chemical interaction, such as hydrogen bond formation in gel formation or the detection of sweetness by the tongue. However, some of the changes in food molecules are more biological in character – when reactions depending on enzymic catalysis are involved. Many of these reactions have been recognised for a long time but other enzyme based processes are quite novel. It was therefore important that this book now includes a chapter devoted to the mechanics, and applications, of enzyme catalysed reactions.

Issues of flavour and texture may seem somewhat superficial, even cosmetic, compared with the role of food as a supplier of essential nutrients, and as a vehicle for natural and man-made toxins. However, these apparently superficial aspects of food are actually of great importance. Nutritionists, physiologists and other scientists now recognise what consumers have always known – there is much more to the business of feeding people than assembling a list of nutrients in the correct proportions. This might be obvious in the supply of food in relatively affluent communities but it is just as true if one is engaged in famine relief. To satisfy a nutritional need a foodstuff must be acceptable, recognised for what it is, and that means looking and tasting "right".

We are now much more aware of two other aspects of our food. First, as some of us have become more affluent, our food intake is no longer limited by our income and we have begun to suffer from the Western "disease" of overnutrition. Food scientists are called upon to devise butter substitutes with minimal fat content, low sugar but tasty breakfast cereals and low salt/low fat snack foods. Closely associated with this issue is the intense public interest in the "chemicals" in our food. The author's very first chemistry teacher, Mr Crosland, refused to accept the word "chemical" as a noun and it is a great pity that this point of view has never found wider acceptance. The general public's appreciation of the language of chemistry continues to leave much to be desired – a situation the popular media never hesitates to exploit. The result is that it is unlikely that many people would buy coleslaw from the delicatessen if it carried a label like this[iv]:

> Active ingredients:
> ethanoic acid, α-D-glucopyranosyl-(1,2)-α-D-fructofuranose, *p*-hydroxybenzyl and indoylmethyl glucosinolates, *S*-propenyl and other *S*-alkyl cysteine sulfoxides, β-carotene (and other carotenoids), phosphatidylcholine.

The issue of chemicals in food is closely linked to the pursuit of "naturalness" as a supposed guarantee of "healthiness". The enormous diversity of the foodstuffs consumed by *Homo sapiens* as a colonist of this planet makes it impossible to define the ideal diet. Diet-related disease, including starvation, is a major cause of death but it appears that while choice of diet can certainly influence the manner of our passing, diet has no influence on its inevitability. As chemists work together with nutritionists, doctors, epidemiologists and other scientists to understand what it is we are eating and what it does to us, we will come to understand the essential compromises the human diet entails. After all, our success on this planet is to some extent at least owed to our extraordinary ability to adapt our eating habits to what is available in the immediate environment. Whether that environment is an arctic waste, a tropical rain forest or a hamburger-infested inner city, humans actually cope rather well.

[iv]The spelling of sulfur compounds throughout this book with *f* rather than *ph* is in deference to the rules of the International Union of Pure and Applied Chemistry (IUPAC) rather than Webster's dictionary.

This book sets out to introduce the chemistry of our diet. Chapters 2–5 and 13 cover food's macro-components, carbohydrates, lipids, proteins and water, and are more overtly chemical in character. These are the substances whose chemical properties exert the major influence on the obvious physical characteristics of foodstuffs. If we are to understand the properties of food gels we are going to need a firm grasp of the chemical properties of polysaccharides. Similarly we will not properly understand the unique properties that cocoa butter gives to chocolate without becoming involved in the crystallography of triglycerides.

Chapters 6–11 are devoted to substances drawn together by the nature of their contribution to food, for example as colours, vitamins, *etc.* rather than by their chemical classification. Although this means that less attention can be devoted to the chemical behaviour of these substances individually, there is still much that the chemists can contribute to our understanding of flavour, appearance and nutritional value. Science is rarely as tidy as one might wish and it is inevitable that some food components have found their way into chapters where they do not really belong. For example, some of the flavonoids mentioned in Chapter 6 make no contribution to the colour of food. However, in terms of chemical structure they are closely related to the flavonoid anthocyanin pigments and Chapter 6 may be regarded as as good a location for them as any.

Chapter 12 is devoted to enzymes. It is the reactions that enzymes catalyse that reveal their presence to us, rather than their chemical nature. All life depends on the activity of enzymes and every foodstuff, being biological in nature, comes to us in its raw state containing a multitude of different enzymes. Most we can ignore, some we need to inactivate to ensure stability of nutrients *etc.*, but others we have learned to exploit in the production of many food products.

The final chapter, Chapter 13, is devoted to water. Apparently the simplest food component, and certainly the most abundant, it remains one of the most poorly understood. It could be placed at the beginning of this book, as reviewers of previous editions have sometimes suggested, but it is feared that much of water's chemistry would be so intimidating as to prevent many readers penetrating to the tastier chapters.

This book does not set out to be a textbook of nutrition; its author is in no way qualified to make it one. Nevertheless food chemists cannot ignore nutritional issues and wherever possible the links between the subtleties of the chemical nature of food components and nutritional and health issues have been pointed out. Similarly, students of nutrition should find a greater insight into the chemical background of their subject valuable. It is also to be hoped that health pundits who campaign for the reduction or increase of this or that component of our diet will gain a better appreciation of exactly what it is they are demanding, and what the knock-on effects might be.

Food chemists should never overlook the fact that the object of their study is not just another, albeit fascinating, aspect of applied science. It is all about what we eat, not just to provide nutrients for the benefit of our bodies but also to give pleasure and satisfaction to the senses. Not even the driest old scientist compliments the cook on the vitamin content of the food on his plate – it's the texture and flavour, and the company around the table, that wins every time.

FURTHER READING

H. McGee, *On Food and Cooking*, Unwin Hyman, London, 1984.

J. Burnett, *Plenty and Want: A Social History of Diet in England from 1815 to the Present Day*, Routledge, London, 3rd edn, 1989.

M. Toussaint-Samat, *History of Food*, Blackwell, Cambridge, MA, USA, 1992.