# Food Science

## A chemical approach

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# a chemical approach

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HODDER AND STOUGHTON
LONDON SYDNEY AUCKLAND TORONTO

ISBN 0 340 20962 3 Unibook

First published as *A Chemical Approach to Food and Nutrition* 1961
Second edition 1970
Reprinted 1972, 1973, 1975 (with minor amendments), 1976
Third edition 1977
Reprinted 1978 (with additions), 1980, 1981



Printed in Great Britain for
Hodder and Stoughton Educational,
a division of Hodder and Stoughton Ltd,
Mill Road, Dunton Green, Sevenoaks, Kent,
by Richard Clay (The Chaucer Press) Ltd,
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# Preface to third edition

It is hoped that this book will be of interest and value to all who are concerned with elementary food science. In particular, it is intended for students of Food Science and Technology, Home Economics, Catering and Nutrition. It should prove useful for G.C.E. Advanced level studies in schools and for O.N.D. and H.N.D. courses in Colleges of Further Education. Students of Medicine and Nursing should find it of interest as background reading.

The incentive for writing this book was the discovery, made while teaching Food Chemistry, that there was no good text available which combined, at a fairly elementary level, a discussion of the chemical nature of food with a description of what happens to food when it is cooked or processed and when it is eaten. The pages which follow are an attempt to make good this deficiency.

The first three short chapters, which are deliberately simple and descriptive, present a general account of the nature of food and enzymes, and what happens to food in the body. They are followed by a chapter which deals with basic chemistry which will assist those whose knowledge of the subject is rudimentary or dormant. Readers who have a basic knowledge of the subjects covered in these preliminary chapters are invited to start at Chapter 5 in which the main chemical themes of the book start to unfold.

Chapters 5 to 11 contain an account of the chemical nature of the various classes of nutrients and of important members of those classes. The processes used in the manufacture and treatment of foods have been discussed where appropriate, and attention has been given to the changes which occur when food is cooked. To complete the picture the fate and functions of foods in the body have been described, albeit in a somewhat condensed and simplified form.

A complete chapter is devoted to Cooking and Diet reflecting the belief of both authors and reviewers that this practical application of

food science needs to be emphasized. The treatment of food preservation in Chapter 13 is fairly extensive and sections on food spoilage and food poisoning are included. The final chapter deals with the important and controversial topic of additives in food and the extended treatment given includes a discussion of legal requirements.

In this new third edition revisions and updating have taken place throughout the text without changing the general format of the previous edition. Some diagrams and most tables have been modified. The greatest changes occur in the last two chapters which have been substantially rewritten to take into account the many changes and advances of the last seven years. The nature of the changes in this edition can be gauged more clearly by reading *Perspectives in food science* which follows this preface.

We have not attempted to provide references to the original sources of the information given in this book; such references would greatly increase the length and cost of the book and would, we feel, be used by relatively few readers. A short list of papers and books recommended for further reading is given at the end of most chapters; the papers cited are review articles which extend the information given in the chapter concerned. We have tried to make these lists selective rather than comprehensive. A list of books of more general interest is included at the end of the book.

All figures relating to the nutrient content of foods contained in this edition are taken from *The Composition of Foods* and we should like to acknowledge our debt to McCance and Widdowson, the original authors, and to Paul and Southgate, who have been responsible for the new material in the 4th edition (1978).

B.A.F.
A.G.C.

# Perspectives in food science

The subject of Food Science and Nutrition is one of endless fascination partly because of the inherent interest of the subject and partly because knowledge is increasing and new techniques are being developed at a rapid rate.

In a world-wide context perhaps one of the most significant developments of recent years has been a re-appraisal of protein requirements. Many people now consider that protein requirements for adults have been overstated (p. 219) and that whereas previously it was thought that there was a protein deficiency or *protein gap* in many parts of the world it is now considered that there is an energy gap. In practical terms this means that international bodies, such as W.H.O. and F.A.O., need to redirect efforts previously aimed at increasing provision of protein foods into ways of improving total food production. Although in Great Britain there is no shortage of protein, the high cost of animal protein has led to the development of novel protein foods (p. 220) of vegetable origin.

An area of growing interest and concern is that of diet and disease. There is an increasing realization that many people are too fat and that obesity is a threat to health; hence a growing interest in slimming (p. 301). The evidence linking diet with coronary heart disease has encouraged many to reappraise the place of sugar (p. 141) and animal fats (p. 129) in the diet. The effect of fibre in the diet is currently a matter of much debate and research (p. 187) and the general relationship between diet and health is now one of much public interest.

The increasing importance of convenience foods is accompanied by the growing dominance of supermarkets in the High Street. It comes as something of a shock to realize that by 1970 world sales of processed potatoes were greater than those of fresh ones and that by 1975 most potatoes eaten in the U.S.A. were in convenience form. Among the different types of convenience food it is frozen foods (p. 321) that have

advanced most rapidly though new techniques of heat sterilization (p. 325) show much promise for the future. The application of freezing to improved methods of catering, particularly in schools and hospitals, is gradually increasing in importance (p. 323) as is the use of cheap vegetable protein foods in convenience form (p. 220).

The development of new convenience foods has resulted in the use of an increasing amount and variety of additives and consequently much new legislation to control their use (Chapter 14). In addition Great Britain's membership of the E.E.C. requires a long process of harmonization of our food laws with those of other member countries (p. 350). New classes of additive have been defined and their use controlled by law (p. 358). The problems of the possible toxicity of additives have continued to earn a high priority in research resulting, for example, in the discontinuation of some coal-tar dyes previously allowed as food colours (p. 351) and a reappraisal of artificial sweeteners (p. 355) to mention but two examples.

Finally, recent years have seen a number of changes in the units in which food values and weights and measures are expressed. For example, the joule is finding increasing acceptance as a unit expressing the energy value of food (p. 17), while international units previously used to express vitamin content are being replaced by metric units (p. 249). In addition protein quality is being assessed with greater meaning in terms of biological value and chemical scores (p. 206). Imperial units used for measuring weight and volume are rapidly disappearing and being replaced by metric equivalents, though the time-honoured pint for milk and beer remain as reminders of the 'good old days' (p. 365).

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Some people have a foolish way of not minding, or of pretending not to mind, what they eat. For my part, I mind my belly very studiously and very carefully; for I look upon it that he who does not mind his belly will hardly mind anything else.

SAMUEL JOHNSON

Chapter One

# Food and its functions

The basic function of food is to keep us alive and healthy, and in this book we shall consider how food does this, although we shall also need to think about many other related matters. Indeed we cannot answer such a fundamental 'How' question without first finding out the answer to some simpler 'What' questions, such as what is food, what happens to it when it is stored, processed, preserved, cooked, eaten and digested. The answers to such questions can only be found out by experiment, and many different sciences play a part in helping to provide the answers. In recent years the study of food has been accepted as a distinct discipline of its own and given the name *food science*.

It is a good deal easier to suggest the term food science than to define it and it is difficult to improve on the definition of J. R. Blanchfield that it is 'a coherent and systematic body of knowledge and understanding of the nature, composition and behaviour under various conditions, of food materials'. The basic sciences of mathematics, physics, chemistry and biology are all involved as are the newer sciences of biochemistry and microbiology. Yet food science is more than the sum of these separate disciplines, for it is a subject with its own outlook. It is, in a sense, a 'pure applied science' in that it exists not only to pursue academic knowledge, but also to promote the fulfilment of a basic human need—the need for a diet that will sustain life and health. Thus to be effective food science must be applied and this is the province of *food technology*.

The dividing line between the science and the technology of food is often blurred because the latter uses and exploits the knowledge of the former. The link between food science and food technology is well exemplified in considering how to solve what must be the foremost problem of our day; namely that of how to feed adequately the world's rapidly expanding population. The problems involved in determining

what foods best meet the dietary needs of different countries, of what constitutes an adequate diet, of the nutritional merits of various new foods, of how to store and preserve food with minimum nutritional loss; these are the province of food science. But in order to use this information it must be applied—food must be grown, stored, processed, preserved and transported on a large scale, and this is the province of food technology.

Although food science embraces many sciences, a chemical approach to the subject is both a natural and an important one. In the first place, although food materials may be complex mixtures of substances, they are composed entirely of chemical compounds. Some people find it hard to accept that all food is chemical but notwithstanding this it is a scientific fact, and the foundation upon which this book is constructed. In the second place, nearly all manufactured foods include 'additives', and these substances, whether they are added to improve colour, flavour, texture or other qualities, are nothing but chemical compounds. Then again, the changes that occur in food when it is stored, processed, cooked, eaten and used by the body are chemical changes. Even the agents that bring about many of these changes both within and without the body, and which are discussed in the next chapter, are chemical substances.

Further insight into the nature and properties of food is gained by considering physical–chemical aspects. For example, many food systems are colloidal in nature and can best be considered as colloidal systems; emulsions and emulsification provide one important example. Physical conditions, such as temperature and pressure often have pronounced effects upon food systems and the rate at which changes occur. Also changes that occur during food preparation—both on a small and large scale—are often primarily physical ones.

Having defined food science and put forward reasons for making a primarily chemical approach to the subject, we must now define what we mean by the term food. Only those substances which, when eaten and absorbed by the body, produce energy, promote the growth and repair of tissues or regulate these processes, are foods. The chemical components of food which perform these functions are called *nutrients* and it follows that no substance can be called a food unless it contains at least one nutrient. Some particularly valuable foods, such as milk, contain such a variety of nutrients that they can fulfil all the functions of food mentioned above, while others, such as glucose, are composed entirely of a single nutrient and have only a single function. The study of

the various nutrients in relation to their effect upon the human body is called *nutrition.*

**Types of Nutrient**

Nutrients are of six types, all of which are present in the diet of healthy people. Lack of the necessary minimum amount of any nutrient leads to a state of *malnutrition*, while a general deficiency of all nutrients produces *under-nutrition* and, in extreme cases, starvation. The six types of nutrient are: *fats, carbohydrates, proteins, water, mineral elements* and *vitamins.* Apart from the nutrients already mentioned, the body also requires a continuous supply of oxygen. Oxygen is not normally regarded as a nutrient, however, because it is supplied from the air and passes into the body, not through the digestive system, but through the lungs.

Nutrients can be considered from two points of view—their functions in the body and their chemical composition. These two aspects are closely related, nutrient function being dependent upon composition, and in later chapters they will be considered in conjunction with each other, though the main emphasis will be on chemical composition.

The two basic functions of nutrients are to provide materials for growth and repair of tissues—that is to provide and maintain the basic structure of our bodies—and to supply the body with the energy required to perform external activities as well as carrying on its own internal activities. The fact that the body is able to sustain life is dependent upon its ability to maintain its own internal processes. This means that though we may eat all sorts of different foods and our bodies may engage in all sorts of external activities and even suffer injury or illness, yet the internal processes of the body absorb and neutralize the effects of these events and carry on with a constant rhythm. This is only possible because the components of our bodies are engaged in a ceaseless process of breakdown and renewal; a theme to which we shall return.

It is apparent that if the body's internal processes are to be maintained constant in spite of its ceaseless activity, and in the face of external pressures, some form of control must be exercised and, considering the complexity of the body's activities, it is evident that this control must be very precise. Thus nutrients have a third function, namely that of controlling body processes, a function which will be considered in the next chapter.

We have seen that food provides us with nutrients that perform three