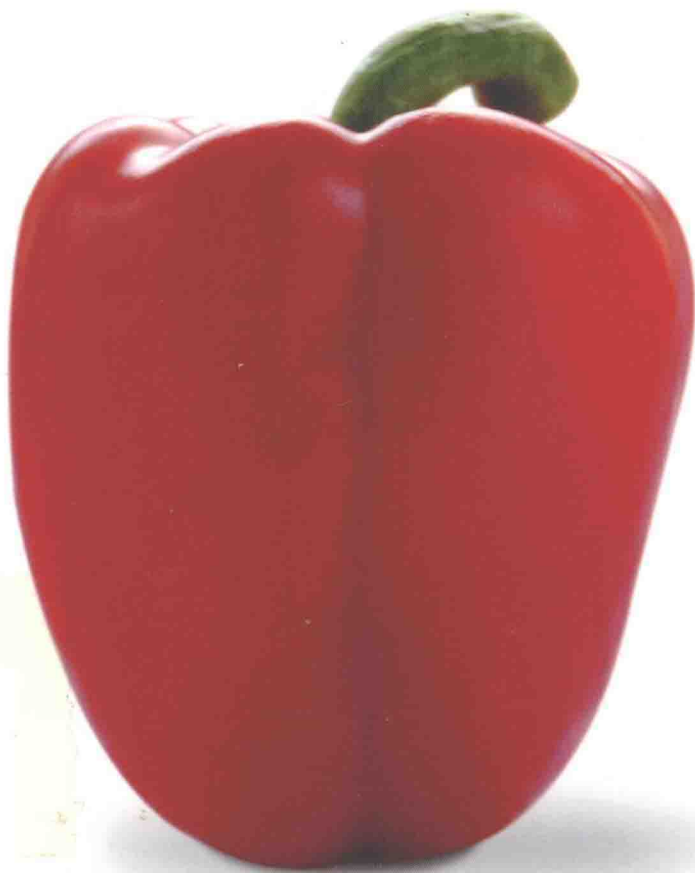


5th Edition

FOOD

The Chemistry of its Components

Tom Coultate



RSC Publishing

Foreword by Heston Blumenthal

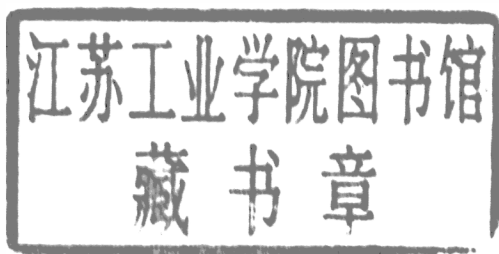
Food

The Chemistry of its Components

5th Edition

T.P. Coultate

formerly of London South Bank University



RSC Publishing

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Foreword

Like science, cuisine thrives on curiosity.

In 1999 I began visiting the flavour and fragrance company Firmenich in Geneva, to exchange ideas and explore culinary science. On one occasion I was in the office of Dr Alan Parker, at the wonderfully named Laboratory for the Physics of Soft Edible Matter, and noticed a shelf full of RSC books with titles that held a lot of appeal for a chef with a growing interest in the molecular properties of food: *Basic Principles of Colloid Science*; *Carbohydrate Chemistry*; *Fatty Acids* and, of course, *Food: The Chemistry of Its Components*.

As soon as I got back to Bray, I looked up the RSC's publications list and ordered lots of their books. Tom's turned out to be particularly useful. Lucid, accessible and clearly expressed, it was exactly the kind of science primer I was looking for. I read it from cover to cover and then invited Tom over to the Fat Duck to find out more.

In person, Tom is just as entertaining and passionate about his subject as he is on the page. It made for a truly stimulating discussion, during which he talked, among other things, about gellan gum – a versatile gelling agent with superb flavour release that has since become a vital part of the kitchen's resources and a key ingredient in a number of the dishes I've created, including amazingly fresh, smooth purées, salmon poached in liquorice, and a cup of tea that appears to be hot and cold at the same time!

Food: The Chemistry of Its Components is full of similarly valuable, thought-provoking information, guaranteed to spark off all kinds of insights and ideas. It deserves to be on the bookshelf not just of every chef and scientist, but of anyone interested in food or how the world around us works.

Heston Blumenthal, Bray, 2008

Preface to the Fifth Edition

When the Royal Society of Chemistry originally invited me to write this book in 1980 the proposed readership was clearly delineated, namely teachers of GCE Advanced Level Chemistry in school sixth forms. Apparently they were badly in need of background information to help them prepare their students for the new topic of Food Chemistry which had appeared in some of their syllabuses. By the time the first edition actually appeared a few years later the need for an up to date textbook of introductory food chemistry to support my own BSc Food Science students, at what was then the Polytechnic of the South Bank, London, was also becoming obvious. The favourable response to the first edition told me that for once two birds had been killed with one stone! As new editions have appeared over the years the original objective has, perhaps inevitably, suffered from what I believe is known in military circles as “mission creep”. This edition is over twice the size of the first, as interesting new topics have demanded attention and chapters devoted to water, minerals and “undesirables” have been added.

My determination to ensure that chemical formulae are included for virtually every food substance mentioned in the text may make the contents look a little intimidating. However, I continue to try to make the actual words as approachable as possible, lending themselves to being read as well as “looked up”. Despite appearances, readers with only the vaguest recollection of school chemistry should find most of it within their grasp, especially in the later chapters. The separate inclusion of more advanced material begun in the fourth edition has now been further developed with the Special Topics included at the end of most chapters.

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As in previous editions, a selection of Further Reading is also included with each chapter, wherever possible restricted to 21st century material. Extensive references to research literature are not provided, but each chapter ends with a selection of articles, headed Recent Reviews. These will be available to most university students and can provide a route to advanced literature. The temptation to include addresses of relevant and authoritative websites has been resisted since, unlike the traditional scientific literature, they tend to be ephemeral and are unlikely to survive through the lifetime of a textbook.

The internet can provide a wealth of information—but it must be used with considerable caution. It has always been the rule that one should not necessarily believe something just because it has appeared in a book, but such scepticism is absolutely essential when exploring websites. For example, an internet search using “choline” and “vitamin” as keywords will locate the official statement that choline is not a vitamin (*see* Chapter 8), followed by innumerable commercial sites which claim the exact opposite, as a means of boosting sales of choline as a “dietary supplement”.

Information on nutrient consumption, exposure to pesticides and similar material is largely based on British sources, a limitation for which I apologise to readers elsewhere in the world. Similarly, where legislation is mentioned, for instance regarding what additives are or are not permitted, the situation in Britain and the European Community is reported for illustrative purposes. The appropriate authorities such as the UK Food Standards Agency must always be consulted for an authoritative view of the legal position.

A BRIEF NOTE ABOUT CONCENTRATIONS

The concentrations of chemical components are expressed in a number of different styles in this book, depending on the context and the concentrations concerned. Readers may find the following helpful.

- (a) However they are expressed, concentrations always imply the amount *contained*, rather than the amount *added*. Thus “5 g of X per 100 g of foodstuff” implies that 100 g of the foodstuff contains 95 g of substance(s) other than X.
- (b) The abbreviation ppm means parts per million, *i.e.* grams per million grams, or more usually milligrams per kilogram. One ppb, or part per billion, corresponds to one microgram per kilogram.
- (c) Amounts contained in 100 g (or 100 cm³) are often expressed as simple percentages. Where necessary the terms w/w, v/v or w/v

are added to indicate whether volumes or weights or both are involved. Thus “5% w/v” means that 100 cm^3 of a liquid contains 5 g of a solid, either dissolved or in suspension. Note that millilitres (ml) and litres (l) are no longer considered acceptable. Although the replacement for the ml, the cubic centimetre (cm^3), is widely recognised, there is little sign that the cubic decimetre, or dm^3 , has yet taken over from the litre—except in teaching laboratories, which of course must always endeavour to toe the party line.

- (d) Very often a strictly mathematical style is adopted, with “per” expressing the power of minus one. Since mathematically:

$$x^{-1} = 1/x$$

$5\text{ }\mu\text{g kg}^{-1}$ becomes a convenient way of writing 5 micrograms per kilogram. This brief but mathematically rigorous style comes into its own when the rates of intake of substances such as toxins have to be related to the size of the animal consuming them, as in “5 milligrams per day per kilogram body weight”, which abbreviates to:

$$5\text{ mg kg}^{-1}\text{ body weight per day}$$

A quantity, say 10 mg, per cubic centimetre, cm^3 , would be written: 10 mg cm^{-3} .

Tom Coultate, 2008

The Author

Until he retired from full-time teaching Tom Coultate was Principal Lecturer in Food Biochemistry at London South Bank University, on courses ranging from HNC to MSc and particularly the BSc in Food Science. He has had a professional interest in food ever since leaving school to join Unilever's Colworth laboratories, where he continued with his studies part-time gaining an ONC (in Chemistry), an HNC (in Applied Biology) and an MIBiol (in Biochemistry). Before taking up teaching he gained a PhD at the University of Leicester for studies on the biochemistry of thermophilic bacteria. Dr Coultate is a Fellow of the Institute of Food Science and Technology. From time to time he contributes articles to food magazines and enjoys giving talks to local societies on food topics.

Acknowledgements

In preparing this fifth edition I have been as dependent as ever on the contributions of my family, colleagues, students and readers of previous editions.

My wife Ann has continued to provide the same invaluable encouragement and support she first contributed over 25 years ago. My sons Edward and Ben, keen amateur photographers, have graduated from helping to spend the royalties to contributing valuable artistic advice on the design of the cover.

Ever since I started work on the first edition I have been dependent on the support of colleagues and friends. They have been an indispensable source of encouragement and ideas, details of the latest research (including their own) and expert guidance through controversial or unfamiliar topics. This list of names is intended to include contributors to all five editions and I sincerely apologise to anyone whose name should be here but isn't:

Jenny Ames, Peter Barnes, Alan Beeby, Martin Chaplin, Barbara Crook, Jill Davies, Peter Ellis, Ailbhe Fallon, Paul Gillard, (the late) Pat Hastilow, John Henley, Nick Henson, Mike Hibbs, (the late) Mike Hill, David Ledward, Dominic Man, Neil Morgan, Bryan Reuben, Sibel Roller, Dave Rosie, Tom Sanders, David Shuker, Ken Spears, Melvyn Stevens, Sam Sumar, Graham Sworn, Geoff Talbot, Jan van Mechelen, Dave Walsh and Robin Wyers.

Of course the opinions expressed in this book, and any errors that remain, must be placed at my door, not theirs. Several organisations have provided essential services, notably the libraries of London South Bank University, the Open University at Milton Keynes and King's College, London University. The regular on-line bulletins from Reading Scientific Services, Ltd., have also kept me aware of the latest

developments. The staff of the UK Food Standards Agency have been a constant source of up to date information on legislative issues. What is recorded in this book was correct at the time of writing, but readers should always consult the FSA or other authorities directly when authoritative information is required about what is or is not currently permitted.

Writing a book like this would not be the rewarding task it is without the support, and often blunt criticism, of my students, for many years at London South Bank University and most recently at King's College, London University. Perhaps they will never improve on the mnemonic for the hexose sugars but they still spot errors, especially in diagrams and formulae, with ruthless efficiency.

As with all previous editions I have been able to rely on my friends at the Royal Society of Chemistry, particularly Janet Freshwater, Katrina Harding and Caroline Wain, for their support and encouragement. Special thanks must go to my editor, Don Sanders. He has done great work repairing the infelicities of my English and made me rethink a number of passages that simply did not actually say what I thought they did!

Finally I come to my friend Heston Blumenthal. Much of my readership has always consisted of students and teachers, of chemistry, food science, nutrition, *etc.*, together with scientists and technicians involved in the food industry and its associated organisations. Until I met Heston it had never occurred to me that what I had to say might be of interest to that other food world, of fine dining and internationally renowned chefs. However when Heston introduced me to “molecular gastronomy” my ideas changed, to say the least. That he has consented to write the Foreword will ensure that this book is not entirely without merit and is for me a great honour for which I am exceedingly grateful.

Tom Coultate, 2008

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CHAPTER 1

Introduction

For the chemists of the 18th and 19th 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.

But by the middle of the 19th century the chemists were deeply involved in exposing the malpractices of food suppliers. Chemistry was brought to bear on the detection of dangerous colourings in confectionery, additional water in milk, beer, wines and spirits, and many other unexpected food ingredients. A major incentive for the development of chemical analysis 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.

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