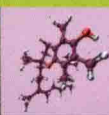




# PHYTONUTRIENTS

Edited by Andrew Salter,  
Helen Wiseman and Gregory Tucker



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Edited by

**Andrew Salter**

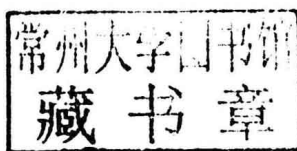
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# Phytonutrients

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## Preface

Plants have been a major source of nutrition for humans ever since the start of our evolution, although more recently we have become more reliant on animal-based foods. This has led to some challenging situations in terms of diet and health and we are encouraged, through schemes such as the 5-A-Day campaign, to consume more plant-based foods. Plants can provide us with almost all of our dietary requirements and this includes macronutrients such as carbohydrates and lipids as well as the wide range of essential micronutrients such as vitamins and minerals. It is also becoming increasingly evident that many other phytochemicals, whilst perhaps not essential, are nonetheless beneficial to our health. These would include the carotenoids, polyphenols and phytoestrogens.

There has long been an interest amongst plant scientists in the enhancement of nutrients within crops. Traditionally this has been brought about by breeding or modifications to agronomic or horticultural practice. More recently this has also been achieved through the application of genetic engineering, for example to enhance levels of vitamins such as vitamin A and folate, or through manipulation of biosynthetic pathways to introduce novel nutrients into plants such as the production of long chain polyunsaturated fatty acids. Such modifications to the plants metabolism often require an intricate knowledge of the metabolic pathways and more specifically their control. Acquisition of this knowledge is greatly facilitated by the rapid progress being made in the areas of transcriptomics, proteomics and systems biology.

These phytonutrients are normally presented in the diet in the form of a complex food matrix. Understanding the interactions between this matrix and the digestive system is a key part of modelling the fate of nutrients in the diet. The plant cell wall for instance can represent a barrier to the release of nutrients and its 'digestibility' in the gastrointestinal tract is a significant factor in determining the bioaccessibility of nutrients. Similarly, the fate of nutrients in terms of how they are able to cross the gut lumen and their subsequent metabolism within the body are also key factors in determining bioavailability and functionality, respectively.

This book contains contributions from both plant scientists and nutritionists. The plant science perspective is primarily about how nutrients are made within the plant and how this may be manipulated to enhance their levels or availability. The nutrition perspective is more on how these food matrices behave during digestion and, more specifically, the functionality of nutrients within the body. It is hoped therefore that this book will be of interest to researchers and students in both of these disciplines. Indeed one of its aims is to encourage understanding, dialogue and collaboration between these two often disparate fields of expertise.

---

# Contributors

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John Brameld is currently Associate Professor of Nutritional Biochemistry at the University of Nottingham. His main interests relate to the regulatory effects of nutrients on gene expression in relation to cell/tissue development, metabolism and function.

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Dr Martin Broadley is a Reader in Plant Nutrition at the University of Nottingham. Martin's research focus is on mineral dynamics in soil-plant systems, including the use of agronomic and genetics-based understanding of mineral improvement of crops (biofortification).

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Professor Judith Buttriss is the Director General at the British Nutrition Foundation, a post she has held since 2007; prior to this she was the Foundation's Science Director since 1998. She is a public health nutritionist with an interest in a broad range of nutrition topics.

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Food Sciences Division, University of Nottingham, Sutton Bonington Campus, Loughborough, Leicestershire, LE12 5RD, UK.

Dr David Gray gained his PhD in the field of plant lipid biochemistry and is now an Associate Professor in Food Chemistry. His research includes an exploration of novel ways of delivering healthy oils to foods, with minimum loss to oil quality and minimum impact on the environment.

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Dr. Flores-Perez obtained her PhD degree at CRAG, where she developed her interest in the regulation of plant carotenoid biosynthesis and biotechnology. She is currently a postdoctoral fellow working on plastid import mechanisms at the Department of Biology, University of Leicester, University Road, Leicester LE1 7RH, UK.

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Dr. Rodriguez-Concepcion is a Research Professor at CRAG, where he leads a group working on the regulation of isoprenoid and carotenoid biosynthesis. His research has unveiled a number of molecular mechanisms used by plant cells to control the supply of carotenoid precursors and their channelling to the carotenoid pathway at transcriptional and post-transcriptional levels.

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Dr Stéphane Ravanel is a plant biochemist and molecular biologist with a long-standing interest in the metabolism of amino acids and folates.

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Professor Spencer is Leader of the Food Chain and Health sub-theme “Plant Bioactives and Health” within Food and Nutritional Sciences at Reading University. His interests are focused on investigating the molecular mechanisms that underlie the accumulating body of epidemiological, and medical anthropological evidence, on a positive correlation between the consumption of diets rich in fruits and vegetables and a decreased risk of neurodegenerative disorders.

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Greg Tucker is Professor of Plant Biochemistry at Nottingham University. A major area of interest is the molecular basis of quality in fruit and vegetables. This includes

methods to extend the shelf life of these commodities and the impact that this may have on nutritional composition.

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Dr Katerina Vafeiadou is a research fellow at the Hugh Sinclair Unit of Human Nutrition, University of Reading. Dr Vafeiadou has previously carried out research on the effects of dietary flavonoids on both cardiovascular and neurodegenerative diseases, with main focus on flavonoids role in the prevention of inflammation and endothelial dysfunction. Dr Vafeiadou is currently working for a Food Standards Agency project which investigates the impact of replacing dietary saturated fats with either monounsaturated fats or polyunsaturated fats on cardiovascular risk.

### **David Vauzour**

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Dr David Vauzour is a Senior Research Associate at Norwich Medical School, University of East Anglia. Dr Vauzour has carried out many investigations on the influence of phytochemicals on brain health through their interactions with specific cellular signalling pathways pivotal in protection against neurotoxins, in preventing neuroinflammation and in controlling memory, learning and neuro-cognitive performances.

### **Philip J. White**

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Professor Philip J. White is a Senior Research Scientist at Scottish Crop Research Institute (which became The James Hutton Institute w.e.f. April 2011). Philip's research comprises a wide range of subjects within the field of plant mineral nutrition, ranging from molecular genetic through to agronomic scales. He has previously held positions at the Universities of Edinburgh and Cambridge, and Horticulture Research International. He is a Special Professor in Plant Ion Transport at the University of Nottingham, and a Visiting Associate Professor at the Comenius University, Bratislava.

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Dr Helen Wiseman leads the Phytochemical Research Group at King's College London. Dr Wiseman has carried out numerous investigations of the potential health effects of dietary phytochemicals, such as flavonoids, including possible protection against cardiovascular disease, cancer and loss of cognitive function, which may be exerted via a wide range of mechanisms including effects on gene expression, regulatory microRNA and post-translational modification and modulation of cell signalling pathways.



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# Abbreviations

<b>AA</b>	ascorbic acid
<b>ACP</b>	acyl carrier protein
<b>ADC</b>	4-amino-4-deoxychorismate
<b>AdoMet</b>	S-adenosylmethionine
<b>AICAR</b>	aminoimidazole carboxamide ribonucleotide
<b>AICART</b>	aminoimidazole carboximide ribonucleotide transformylase
<b>ALA</b>	alpha linolenic acid
<b>ANR</b>	anthocyanidin reductase
<b>ANS</b>	anthocyanidin synthase
<b>BCO</b>	$\beta$ -carotene-15,15'-oxygenase
<b>cAMP</b>	cyclic AMP
<b>CHD</b>	coronary heart disease
<b>CHI</b>	chalcone flavanone isomerase
<b>CHS</b>	chalcone synthase
<b>CHYB</b>	carotenoid $\beta$ -ring hydroxylase
<b>CHYE</b>	carotenoid $\epsilon$ -ring hydroxylase
<b>CI</b>	confidence interval
<b>COMT</b>	catechol- <i>O</i> -methyltransferases
<b>CRTISO</b>	carotenoid isomerase
<b>CYP</b>	cytochrome P450
<b>CVD</b>	cardiovascular disease
<b>DAG</b>	diacylglycerol
<b>DAHP</b>	D-arabino-heptulosonic acid 7-phosphate
<b>DFE</b>	dietary folate equivalents
<b>DFR</b>	dihydroflavonol reductase
<b>DHA</b>	docosahexaenoic acid
<b>DHA</b>	dehydroascorbate (Chapter 5)
<b>DHAA</b>	dehydroascorbic acid
<b>DHF</b>	dihydrofolate
<b>DHFR</b>	dihydrofolate reductase
<b>DHPS</b>	dihydropteroate synthase
<b>DHQ</b>	3-dehydroquinic acid
<b>DMAPP</b>	dimethylallyl diphosphate
<b>DMPBQ</b>	dimethylphytylbenoquinol
<b>E-4-P</b>	D-erythrose-4-phosphate

<b>EGCG</b>	epigallocatechin gallate
<b>EPSP</b>	3-enolpyruvylshikimic acid 3-phosphate
<b>ER</b>	endoplasmic reticulum
<b>ERK</b>	extracellular signal-related kinase
<b>EPA</b>	eicosapentenoic acid
<b>F3H</b>	Flavanone 3-hydroxylase
<b>FAS</b>	fatty acid synthase complex
<b>FCL</b>	5-formyl-THF cycloligase
<b>FGGH</b>	folylpolyglutamate $\gamma$ -glutamyl hydrolase
<b>FPGS</b>	folylpolyglutamate synthetase
<b>FS</b>	flavone synthase
<b>FTCD</b>	glutamate formiminotransferase/formimino-THF cyclodeaminase
<b>FTHFS</b>	10-formyl-THF synthetase
<b>GAR</b>	glycinamide ribonucleotide
<b>GART</b>	glycinamide ribonucleotide transformylase
<b>GBSS</b>	granule bound starch synthase
<b>GDC</b>	glycine decarboxylase
<b>GI</b>	gastrointestinal tract
<b>GGPP</b>	geranylgeranyl pyrophosphate
<b>GGR</b>	geranylgeranyl reductase
<b>GH</b>	glycosyl hydrolase
<b>GLA</b>	gamma linolenic acid
<b>GLUT</b>	glucose transporter
<b>GSH</b>	glutathione
<b>GSHPx</b>	glutathione peroxidase
<b>GT</b>	glycosyl transferase
<b>GTPCHI</b>	GTP-cyclohydrolase I 7,8-dihydroneopterin (DHN) triphosphate
<b>HBA</b>	hydroxybenzoic acids
<b>HCA</b>	hydroxycinnamic acids
<b>HDL</b>	high density lipoproteins
<b>HO-1</b>	haem oxygenase 1
<b>HPPK</b>	hydroxymethyldihydropterin pyrophosphokinase
<b>IFS</b>	isoflavone synthase
<b>IMP</b>	inosine monophosphate
<b>IPP</b>	isopentenyl diphosphate
<b>JNK</b>	c-jun amino-terminal kinase
<b>KPHMT</b>	ketopantoate hydroxymethyl transferase
<b>LA</b>	linoleic acid
<b>LAR</b>	leucoanthocyanidin reductase
<b>LCYB</b>	lycopene cyclase B
<b>LCYE</b>	lycopene cyclase E
<b>LDL</b>	low density lipoprotein
<b>MAPK</b>	MAP kinase signalling pathway
<b>MATE</b>	multidrug and toxin extrusion transporter
<b>MDHA</b>	monodehydroascorbate

<b>MEP</b>	methylethritol 4-phosphate pathway
<b>MGGBQ</b>	2-methy-6-phytylbenzoquinol
<b>MPBQ</b>	2-methy-6-phytylbenzoquinol
<b>MRP</b>	multidrug resistance-associated proteins
<b>MS</b>	methionine synthase
<b>MTF</b>	methionyl-tRNA transformylase
<b>MTHFC</b>	5,10-methenyl-THF cyclohydrolase
<b>MTHFD</b>	5,10-methylene-THF dehydrogenase
<b>MUFA</b>	monounsaturated fatty acid
<b>NSP</b>	non starch polysaccharide
<b>NTD</b>	neural tube defects
<b>ODA</b>	octadecatetraenoic acid
<b>pABA</b>	para-aminobenzoic acid
<b>pABAGlu<sub>n</sub></b>	<i>p</i> -aminobenzoyl(poly)glutamate
<b>PAL</b>	phenylalanine ammonia lyase
<b>PC</b>	phosphatidylcholine
<b>PDP</b>	phytyl pyrophosphate
<b>PDS</b>	phytoene desaturase
<b>PE</b>	phosphatidyl ethanolamine
<b>PEP</b>	phosphoenolpyruvate
<b>PMP</b>	phytol monophosphate
<b>PPAR</b>	peroxisome proliferator activated receptor
<b>PSI</b>	photosystem 1
<b>PSY</b>	phytoene synthase
<b>PUFA</b>	polyunsaturated fatty acid
<b>QTL</b>	quantitative trait loci
<b>RALDH</b>	NAD <sup>+</sup> -dependent retinal dehydrogenase
<b>RDA</b>	recommended dietary allowance
<b>RDH</b>	retinol dehydrogenase
<b>ROS</b>	reactive oxygen species
<b>RR</b>	relative risk
<b>SBE</b>	starch branching enzyme
<b>SDE</b>	starch debranching enzyme
<b>SFA</b>	saturated fatty acid
<b>SHMT</b>	serine hydroxymethyl transferase
<b>SVCT</b>	sodium vitamin C co-transporters
<b>TAG</b>	triacyl glycerol
<b>TAL</b>	tyrosine ammonia lyase
<b>TG</b>	triglycerides
<b>THF</b>	tetrahydrofolates
<b>TS</b>	thymidylate synthase
<b>UFGT</b>	UDP glucose-flavonoid 3- <i>O</i> -glucosyl transferase
<b>UGT</b>	UDP-glucuronosyltransferases
<b>VAD</b>	vitamin A deficiency
<b>VDE</b>	violaxanthin de-epoxidase

<b>VLDL</b>	very low density lipoproteins
<b>XET</b>	xyloglucan endo transglycosylase
<b>ZDS</b>	ζ-carotene desaturase
<b>ZEP</b>	zeaxanthin eopxidase

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