

---

# NRR

## NUTRITION RESEARCH REVIEWS

---

Volume: 25

---

Number: 1

---

June 2012

---

Available online at  
[www.journals.cambridge.org](http://www.journals.cambridge.org)

# Nutrition Research Reviews

Volume 25, 2012 ISSN: 0954-4224

## Aims and Scope

*Nutrition Research Reviews* publishes comprehensive and challenging review articles on selected key topics in nutritional science. Authors are encouraged to take a critical approach in appraising the literature while also aiming to advance new concepts and hypotheses. The journal publishes both solicited and unsolicited articles.

*Nutrition Research Reviews* is published twice a year by Cambridge University Press on behalf of The Nutrition Society.

The contents page of this journal is available on the Internet before publication at [www.cambridge.org/nrr](http://www.cambridge.org/nrr)

---

## Editorial Board

### Editor-in-Chief

Dr Graham C Burdge, *University of Southampton, UK*

### Address for correspondence

Dr Graham C Burdge, *Editor-in-Chief, Nutrition Research Reviews, Institute of Human Nutrition / DOHaD Division, Institute of Developmental Sciences Building, Mail point 887, Southampton General Hospital, Tremona Road, Southampton SO16 6YD, UK*

Tel: +44(0)23 80798663 Fax: +44(0)23 80795255 Email: [G.C.Burdge@soton.ac.uk](mailto:G.C.Burdge@soton.ac.uk)

### Deputy Editor

Dr Jos Houdijk, *Scottish Agricultural College, UK*

### Editors

Dr M Ashwell, *Baldock, UK*

Dr N Binns, *NMB Consulting Limited, Ireland*

Dr D A Bender, *University College London, UK*

Dr J L Black, *Warrimoo, Australia*

Dr D Dardevet, *INRA, France*

Dr C Edwards, *Glasgow University, UK*

Dr J M Hibbert, *Morehouse School of Medicine, USA*

Dr T Hill, *Newcastle University, UK*

Dr J K Lodge, *Northumbria University, UK*

Professor H C Lukaski, *University of North Dakota, USA*

Dr S McCann, *Roswell Park Cancer Institute, USA*

Dr M Pufulete, *University of Bristol, UK*

Dr P Rogers, *University of Bristol, UK*

Professor N W Solomons, *CESSIAM, Guatemala*

Professor C M Weaver, *Purdue University, USA*

Professor M Verstegen, *Wageningen University, Netherlands*

Dr K M Younger, *Dublin Institute of Technology, Ireland*

### Editorial staff

C Goodstein (*Publications Manager*), C Jackson (*Deputy Publications Manager*),

C T Hughes, L Weeks, D Owen and L King (*Publications Officers*)

---

The Nutrition Society has as its objective the advancement of the scientific study of nutrition and its applications to the maintenance of human and animal health.

Application of membership is invited from anyone whose work has contributed to the scientific knowledge of nutrition, whether such work has been in the laboratory, the field or the clinic, and whether experimental, clinical, agricultural or statistical in nature. There is also a student membership scheme with reduced subscriptions.

Particulars of The Nutrition Society and application forms for membership are available from The Nutrition Society, 10 Cambridge Court, 210 Shepherds Bush Road, London W6 7NJ, UK.

Tel: +44 (0)20 7602 0228, Fax: +44 (0)20 7602 1756, Email: [edoffice@nutsoc.org.uk](mailto:edoffice@nutsoc.org.uk)

The Nutrition Society Home Page is at <http://www.nutrition society.org>

# NUTRITION RESEARCH REVIEWS 2012

---

Volume 25 No. 1 June 2012

---

Editor-in-Chief

Dr Graham C. Burdge  
University of Southampton, UK

**CAMBRIDGE**  
UNIVERSITY PRESS

**Nutrition Research Reviews**  
*Volume 25, 2012 ISSN: 0954-4224*

**Publishing, Production, Marketing, and**

**Subscription Sales Office:**

Cambridge University Press  
The Edinburgh Building  
Shaftesbury Road  
Cambridge CB2 8RU, UK

**For Customers in North America:**

Cambridge University Press  
Journals Fulfillment Department  
100 Brook Hill Drive  
West Nyack  
New York 10994-2133  
USA

**Publisher:** Katy Christomanou

*Nutrition Research Reviews* is an international journal published biannually (June and December) by Cambridge University Press on behalf of the Nutrition Society.

**Subscription information:**

Volume 25 2012 (2 issues)  
Internet/print package: £217/\$423 American only/€337 EU only  
Internet only: £161/\$298 Americas only/€241 EU only  
Print only: £204/\$395 Americas only/€311 EU only

**Back volumes** are available. Please contact Cambridge University Press for further information.

**Claims** for non-receipt of journal issues will be considered on their merit and only if the claim is received within six months of publication. Replacement copies supplied after this date will be chargeable.

**US POSTMASTERS:** please send address corrections to *Nutrition Research Reviews*, Cambridge University Press, 100 Brook Hill Drive, West Nyack, New York 10994-2133.

**Information for Authors:** The journal publishes both solicited and unsolicited review articles. For unsolicited material, authors are asked to submit a summary of the article to the Editor-in-chief in the first instance:

Dr Graham C Burdge,  
Editor-in-Chief, Nutrition Research Reviews,  
Institute of Human Nutrition / DOHaD Division,  
Institute of Developmental Sciences Building,  
Mail point 887, Southampton General Hospital,  
Tremona Road,  
Southampton SO16 6YD, UK  
Tel: +44(0)23 80798663  
Fax: +44(0)23 80795255  
Email: [G.C.Burdge@soton.ac.uk](mailto:G.C.Burdge@soton.ac.uk)

**Directions to Contributors:** if not printed in this issue, are available from the Editor-in-chief.

**Offprints:** The author (or main author) of an accepted paper will receive a free PDF of their paper and a voucher copy of the issue in which their paper has been published. Additional offprints are available for a fee and should be ordered at proof stage. **No page charges are levied by this journal.**

**Copyright:** As of July 2000 the copyright of all articles submitted to *Nutrition Research Reviews* are retained by the authors or their institutions. For articles prior to this date permission for reproduction of any part of the journal (text, figures, tables or other matter) in any form (on paper, microfiche or electronically) should be sought directly from the Society, at: The Publications Office, The Nutrition Society, 10 Cambridge Court, 210 Shepherds Bush Road, London W6 7NJ, UK.

**Disclaimer:** The information contained herein, including any expression of opinion and any projection or forecast, has been obtained from or is based upon sources believed by us to be reliable, but is not guaranteed as to accuracy or completeness. The information is supplied without obligation and on the understanding that any person who acts upon it or otherwise changes his/her position in reliance thereon does so entirely at his/her own risk. Neither the Society nor Cambridge University Press accepts responsibility for any trade advertisement included in this publication.

This journal is printed on acid-free paper from renewable sources. Printed in the UK by Bell & Bain Ltd., Glasgow.

This journal issue has been printed on FSC-certified paper and cover board. FSC is an independent, non-governmental, not-for-profit organization established to promote the responsible management of the world's forests. Please see [www.fsc.org](http://www.fsc.org) for information.

Subscribers may register for free access to the electronic version of *Nutrition Research Reviews*. For more information visit the website at: [journals.cambridge.org](http://journals.cambridge.org)

*Nutrition Research Reviews* is covered by the Science Citation Index<sup>®</sup>, Current Contents<sup>®</sup> / Agriculture, Biology & Environmental Sciences, SciSearch<sup>®</sup>, Research Alert<sup>®</sup>, Index to Scientific Reviews<sup>®</sup>, EMBASE/Excerpta Medica, Chemical Abstracts Services, CINAHL<sup>®</sup> Database, CAB ABSTRACTS<sup>®</sup>, Global Health, BIOSIS<sup>®</sup> Database, SIIC Databases

## Contents

Vol. 25 No. 1 June 2012

Protein–phytate interactions in pig and poultry nutrition: a reappraisal <i>P. H. Selle, A. J. Cowieson, N. P. Cowieson &amp; V. Ravindran</i>	
Introduction	1
Protein–phytate interactions	2
Binary protein–phytate complexes	2
Ternary protein–phytate complexes	4
An additional mechanism for protein–phytate interactions	5
Isoelectric points of protein	6
Impact of phytase on amino acid digestibility in individual feedstuffs	6
Implications of binary protein–phytate complexes	7
Interactions between phytate and starch	9
Phytase amino acid digestibility assays	10
Phytase amino acid digestibility assays in poultry	10
Phytase amino acid digestibility assays in pigs	11
The ‘protein effect’ of phytase	12
Conceptual framework for protein–phytate interactions	13
Future research	13
Acknowledgements	13
References	13
The problem of nitrogen disposal in the obese <i>M. Alemany</i>	
Introduction	18
Amino acids as energy substrates: amino-nitrogen sparing	19
Equilibrium between amino-nitrogen and ammonia for urea synthesis	19
The nitric oxide pathway	21
Nitrite and other forms of nitrogen excretion	22
Health consequences of hampered nitrogen excretion in the obese	24
Conclusions	24
Acknowledgements	24
References	24
Peripheral and central mechanisms involved in the control of food intake by dietary amino acids and proteins <i>G. Fromentin, N. Darcel, C. Chaumontet, A. Marsset-Baglieri, N. Nadkarni &amp; D. Tomé</i>	
Introduction	29
Effect of protein and amino acid intake on overall energy intake, body weight and body composition	30
Protein snacks (or loads)	30
Protein diets	31
Peripheral control of amino acids and protein intake	32
Detection of protein and amino acids during digestion and control of food intake by feedback signals	32
Detection of protein and amino acids, post-absorptive signals and feedback signals controlling food intake	34
Protein-induced reduction in eating and central neuronal pathways	35
Conclusion	36
Acknowledgements	36
References	36
Calcium economy in human pregnancy and lactation <i>H. Olausson, G. R. Goldberg, M. A. Laskey, I. Schoenmakers, L. M. A. Jarjou &amp; A. Prentice</i>	
Introduction	40
Methodological considerations	40
Study designs, baseline and reference data	41
Measures of bone mineral content, density and size	41
Measures of bone turnover, mineral metabolism and excretion	43
Calcium intake, absorption and balance	43
Calcium economy in pregnancy and lactation: review of the evidence	44

Contents

Maternal bone mineral mobilisation: bone mineral studies	44
Pregnancy	44
3–6 months lactation	49
Lactation for > 6 months	50
Post-lactation and resumption of menses	51
Maternal bone mineral mobilisation: bone turnover studies	52
Pregnancy	52
Lactation and postpartum	52
Bone mineral mobilisation: osteoporosis and fractures	53
Intestinal absorption and renal excretion of calcium	53
Pregnancy	53
Lactation and postpartum	53
Fetal calcium accretion and breast-milk calcium secretion	53
Regulation of calcium metabolism in pregnancy and lactation	54
Pregnancy	54
Lactation and postpartum	55
Influence of maternal dietary calcium intake on maternal calcium economy and the bone health of mother and child	56
Influence on the mother in pregnancy	56
Influence on the mother in lactation	57
Influence on the mother in later life	57
Influence on the child	57
Influence of maternal vitamin D status on calcium economy and bone health of mother and child	58
Influence on the mother	58
Influence on the child	59
Summary and implications for nutrition policy	59
Acknowledgements	60
References	60
Redefining the impact of nutrition on breast cancer incidence: is epigenetics involved?	
<i>D. Teegarden, I. Romieu, S. A. Lelièvre</i>	
Triangular relationship: breast cancer incidence, gene transcription and nutrition	68
Burden of breast cancer	68
Genomic impact of nutrition	69
Epigenetic regulation	69
Epigenetics and breast cancer	70
Epigenetic modifications and breast cancer initiation	71
Effect of diet on epigenetic imprinting	72
Diet and breast cancer	73
Advantages and limitations of study designs	73
Obesity	74
Epidemiological studies	74
Animal models	75
Mechanisms	76
Epigenetics	76
Relationship of dietary patterns: healthy or Western?	77
Epidemiological studies	77
Animal models	77
Intervention trials	78
Epigenetic studies	78
Soya intake	78
Epidemiological studies	78
Animal and cell models	79
Clinical trials	79
Epigenetic studies	79
Macronutrients	80
Alcohol: epidemiological studies	80
Alcohol: mechanisms	80
Alcohol: epigenetic studies	80
Fat intake: epidemiological studies	80
Fat intake: animal studies	81
Fat intake: mechanisms	81

Contents

Fat intake: epigenetic studies	81
Carbohydrates, glycaemic index and glycaemic load: epidemiological studies	82
Carbohydrates, glycaemic index and glycaemic load: mechanisms	82
Carbohydrates, glycaemic index and glycaemic load: epigenetics	82
Micronutrients	82
Folate: epidemiological studies	82
Folate: animal models	83
Folate: mechanisms	83
Folate: epigenetics	83
Vitamin D	84
Vitamin D: epidemiological studies	84
Vitamin D: animal studies and mechanisms	84
Vitamin D: intervention studies	85
Vitamin D: epigenetics	85
Carotenoids: epidemiological studies	85
Carotenoids: mechanisms	86
Carotenoids: epigenetic studies	86
The complexity of epigenetics and diet interaction	86
Conclusion	87
Acknowledgements	87
References	87

A multidisciplinary reconstruction of Palaeolithic nutrition that holds promise for the prevention and treatment of diseases of civilisation

*R. S. Kuipers, J. C. A. Joordens & F. A. J. Muskiet*

Introduction	96
Environment, nutrients and their interaction with the genome	97
Evolutionary medicine	97
Arguments and counterarguments in evolutionary health promotion	98
Human evolution	99
Changing habitat and increasing brain size	101
Building a big brain	102
The probability of hunting on the savanna	103
Reconstruction of our ancient diet	103
Palaeo-environments	103
<i>Sahelanthropus</i> , <i>Orrorin</i> and <i>Ardipithecus</i>	103
Early <i>Australopithecus</i> species	104
<i>Paranthropus</i> , late <i>Australopithecus</i> and <i>Homo</i> species	104
Comparative anatomy	104
The diet of our closest relatives	104
Teeth morphology and dental microwear	104
Gut morphology, energy expenditure and muscularity	106
Biogeochemistry	106
Evidence from the strontium:calcium ratio	106
Evidence from the barium:calcium ratio	107
Evidence from the $^{13}\text{C}$ : $^{12}\text{C}$ ratio	107
Limited evidence from the $^{15}\text{N}$ : $^{14}\text{N}$ ratio	109
Limited evidence from the $^{18}\text{O}$ : $^{16}\text{O}$ ratio	109
Isotopic data for more recent hominins	110
Conclusions from isotope studies	110
Archeology	110
Living in the water–land ecosystem	111
From hunting–gathering to agriculture	111
Anthropology	112
The hunter–gatherer diet	112
Hunting <i>v.</i> gathering	112
(Patho)physiology	113
Brain-selective nutrients	113
Hunter–gatherer <i>v.</i> ‘Western’ physiology	113
Evidence-based medicine as applied to long-chain PUFA in CVD and depression	114
Long-chain PUFA benefits in pregnancy and early life	115

The influence of environment	115
Dietary reconstruction of the nutrients available in Eastern Africa	116
Dietary changes since the Agricultural Revolution	117
Potential benefits of a Palaeolithic diet	117
Conclusions	118
Acknowledgements	118
References	118
Calcium and vitamin D in obesity	
<i>Q. Song &amp; I. N. Sergeev</i>	
Introduction	130
Obesity and adipose tissue	130
Calcium and obesity	131
Calcium as a cellular regulator	131
Calcium intake	131
Calcium and body mass	131
Vitamin D and obesity	133
Vitamin D as a hormonal and cellular regulator	133
Determination of vitamin D status	133
Vitamin D status and obesity	134
Mechanisms of action of calcium and vitamin D in obesity	134
Calcium intake and faecal fat excretion	134
Intracellular calcium, 1,25-dihydroxyvitamin D <sub>3</sub> and apoptosis	134
1,25-Dihydroxyvitamin D <sub>3</sub> induces Ca <sup>2+</sup> -mediated apoptosis in adipocytes	136
Calcium and lipid metabolism	137
Vitamin D and mitochondrial uncoupling proteins	138
Conclusion	138
Acknowledgements	138
References	138
A critical review of recommendations to increase dietary protein requirements in the habitually active	
<i>L. S. Lamont</i>	
Introduction to the scientific dialogue	142
Exercise studies using field-based metabolic balance	143
Exercise tracer studies	144
Time for a new approach?	146
Conclusions	147
Acknowledgements	147
References	147
Excess body fat in obese and normal-weight subjects	
<i>E. L. Thomas, G. Frost, S. D. Taylor-Robinson &amp; J. D. Bell</i>	
Introduction	150
Current status of knowledge	150
BMI and adiposity	150
Waist circumference	151
Enhanced adiposity phenotyping	152
Body composition by whole-body MRI and magnetic resonance spectroscopy	153
Metabolically normal obesity	154
Excess body fat in normal-weight subjects	154
Obesity in lean tissue – the problem of ectopic fat	155
Life-style changes and body adiposity	157
Acknowledgements	157
References	157
The role of biomarkers in evaluating human health concerns from fungal contaminants in food	
<i>P. C. Turner, B. Flannery, C. Isitt, M. Ali &amp; J. Pestka</i>	
Background	162
<i>Aspergillus</i> and <i>Fusarium</i> mycotoxins	163
Biomarkers of exposure	163
Aflatoxins	163



*Contents*

Fumonisin	165
Deoxynivalenol	166
Mycotoxins and human disease	168
Aflatoxins and liver cancer	168
Aflatoxins and growth faltering	170
Aflatoxin–albumin exposure patterns in infants	170
Aflatoxin biomarker levels are associated with growth faltering	170
Aflatoxin and gastrointestinal toxicity	170
Aflatoxin and zinc	171
Aflatoxin and insulin-like growth factor	171
Fumonisin B, deoxynivalenol and growth faltering	171
Fumonisin and neural tube defects	172
<i>Fusarium</i> mycotoxins and cancer	173
Conclusions	173
Acknowledgements	174
References	174
Nutrition and the psychoneuroimmunology of postpartum depression	
<i>E. R. Ellsworth-Bowers &amp; E. J. Corwin</i>	
Introduction	180
Overview of postpartum depression and psychoneuroimmunology	180
Nutrition and the psychoneuroimmunology of postpartum depression	180
Critical review: micronutrient links to the psychoneuroimmunology of postpartum depression	183
PUFA	183
Linkage to psychoneuroimmunology	183
Role in depression	183
Role in postpartum depression	184
Assessment of research potential <i>n</i> -3 PUFA and the psychoneuroimmunology of postpartum depression	184
B vitamins	184
Linkage to psychoneuroimmunology	184
Role in depression	184
Role in postpartum depression	185
Assessment of research potential: B vitamins and the psychoneuroimmunology of postpartum depression	185
Vitamin D	185
Linkage to psychoneuroimmunology	185
Role in depression	185
Role in postpartum depression	186
Assessment of research potential: vitamin D and the psychoneuroimmunology of postpartum depression	186
Trace minerals	186
Linkage to psychoneuroimmunology	186
Role in depression	186
Role in postpartum depression	187
Assessment of research potential: trace minerals and the psychoneuroimmunology of postpartum depression	187
Discussion	188
Research design recommendations	188
Limitations	189
Research significance	189
Acknowledgements	189
References	189