

90101 99M 001 00

INSTITUTO NACIONAL  
DE SAÚDE  
DR. RICARDO JORGE  
BIBLIOTECA  
LN.º 15326

# Improving the fat content of foods

Edited by  
**Christine Williams and Judith Buttriss**



**CRC Press**  
Boca Raton Boston New York Washington, DC

**WOODHEAD PUBLISHING LIMITED**  
Cambridge England

# Contents

<i>Contributor contact details</i> .....	xiii
--	------

## Part I Dietary fats and health

<b>1 Health problems associated with saturated and <i>trans</i> fatty acids intake</b> .....	3
<i>P. L. Zock, Unilever Research and Development Vlaardingen, The Netherlands</i>	
1.1 Introduction .....	3
1.2 Saturated and <i>trans</i> fatty acids in the diet .....	4
1.3 Metabolism of dietary fats and blood lipoproteins .....	6
1.4 Dietary fats and the risk of coronary heart disease .....	7
1.5 Dietary fats, obesity, diabetes and cancer .....	18
1.6 Implications: controlling fat intake .....	19
1.7 Future trends .....	20
1.8 Sources of further information .....	21
1.9 References .....	21
<b>2 Dietary fatty acids, insulin resistance and diabetes</b> .....	25
<i>D. I. Shaw, University of Reading, UK, W. L. Hall, King's College London, UK and C. M. Williams, University of Reading, UK</i>	
2.1 Introduction .....	25
2.2 Adverse effects of fatty acids on glucose and insulin .....	26
2.3 Evidence from animal studies .....	33
2.4 Evidence from human studies .....	35

2.5	Conclusions: fatty acids and insulin sensitivity .....	41
2.6	Future trends .....	42
2.7	Sources of further information .....	42
2.8	References .....	43
<b>3</b>	<b>Lipid-gene interactions, diet and health .....</b>	<b>49</b>
	<i>D. Lairon and R. P. Planells, INSERM, France</i>	
3.1	Introduction .....	49
3.2	Genetic influences on lipid metabolism .....	51
3.3	Genetic influences on the uptake and absorption of cholesterol .....	56
3.4	Genetic influences on the metabolic syndrome .....	59
3.5	Dietary fatty acids and the regulation of gene expression ....	61
3.6	Conclusions: lipid-gene interactions and personalized nutrition .....	65
3.7	References .....	66
<b>4</b>	<b>Health benefits of monounsaturated fatty acids .....</b>	<b>71</b>
	<i>J. López-Miranda, P. Pérez-Martínez and F. Pérez-Jiménez, Hospital Universitario Reina Sofía – Córdoba, Spain</i>	
4.1	Introduction .....	71
4.2	Lipoprotein metabolism .....	72
4.3	LDL oxidation .....	75
4.4	Endothelial function .....	76
4.5	Dietary monounsaturated fat and haemostasis .....	78
4.6	Blood pressure .....	85
4.7	Energy balance .....	86
4.8	Carbohydrate metabolism .....	87
4.9	MUFA and cardiovascular risk .....	90
4.10	Dietary monounsaturated fat and cancer .....	91
4.11	Future trends .....	92
4.12	Sources of further information .....	93
4.13	Conclusions .....	94
4.14	Acknowledgements .....	94
4.15	References .....	94
<b>5</b>	<b>Health benefits of polyunsaturated fatty acids (PUFAs) .....</b>	<b>107</b>
	<i>A. M. Miniñane and J. A. Lovegrove, University of Reading, UK</i>	
5.1	Introduction .....	107
5.2	Polyunsaturated fatty acid structure, dietary sources and biosynthesis .....	108
5.3	Metabolism of fatty acids .....	110
5.4	Cardiovascular disease .....	115
5.5	Insulin resistance .....	121
5.6	Colorectal cancer .....	122

5.7	Inflammation and autoimmune diseases .....	124
5.8	Cognitive function .....	125
5.9	Recommendations for population fat intake .....	126
5.10	Genotype and responsiveness to dietary PUFA changes .....	128
5.11	Conclusions and future trends .....	128
5.12	References .....	129
<b>6</b>	<b>Dietary fat and obesity .....</b>	<b>141</b>
	<i>P. Schrauwen and W. H. M. Saris, Maastricht University, The Netherlands</i>	
6.1	Introduction .....	141
6.2	Epidemiological associations .....	143
6.3	Intervention studies: managing fat intake to control obesity ..	146
6.4	Laboratory studies in humans .....	150
6.5	Implications for food processors .....	154
6.6	Conclusions and future trends .....	155
6.7	References .....	156
<b>7</b>	<b>Specific fatty acids and structured lipids for weight control ...</b>	<b>162</b>
	<i>M. S. Westerterp-Plantenga, Maastricht University, The Netherlands</i>	
7.1	Introduction .....	162
7.2	Functionality of lipids .....	162
7.3	Metabolic satiety and fat oxidation: effects of conjugated linoleic acid and diacylglycerol .....	168
7.4	The role of high- and low-fat diets .....	173
7.5	Weight control, fatty acids and structured lipids: a synthesis	175
7.6	Future trends .....	176
7.7	References .....	176
<b>8</b>	<b>Conjugated linoleic acids (CLAs) and health .....</b>	<b>182</b>
	<i>P. Yaqoob and S. Tricon, University of Reading, UK and G. C. Burdge and P. C. Calder, University of Southampton, UK</i>	
8.1	Introduction .....	182
8.2	CLA and body composition .....	183
8.3	Incorporation of CLA into tissue lipids and CLA metabolism in humans .....	191
8.4	CLA and blood lipids .....	193
8.5	CLA and insulin sensitivity .....	197
8.6	CLA, immune function and inflammation .....	198
8.7	CLA and breast cancer .....	200
8.8	Implications for food processors .....	201
8.9	Future trends .....	203
8.10	References .....	203

**Part II Reducing saturated fatty acids in food**

<b>9 The role of lipids in food quality</b> .....	213
<i>Z. E. Sikorski, Gdańsk University of Technology, Poland, and G. Sikorska-Wisniewska, Medical Academy of Gdańsk, Poland</i>	
9.1 Introduction .....	213
9.2 The contribution of lipids to the colour of foods .....	216
9.3 The role of lipids in the flavour of foods .....	219
9.4 Lipids and the texture of foods .....	225
9.5 Lipids and the nutritional value of infant foods .....	228
9.6 Future trends .....	232
9.7 References .....	233
<b>10 Gaining consumer acceptance of low-fat foods</b> .....	236
<i>L. Lähteenmäki, VTT Biotechnology, Finland</i>	
10.1 Introduction .....	236
10.2 Consumer preferences for fat in food products .....	238
10.3 Fat and health: awareness among consumers .....	242
10.4 Promoting low-fat food products and diets .....	244
10.5 Strategies to gain consumer acceptance of low-fat products .....	246
10.6 Future trends .....	248
10.7 References .....	249
<b>11 Optimising dairy milk fatty acid composition</b> .....	252
<i>D. I. Givens, University of Reading, UK and K. J. Shingfield, MTT AgriFood Research Finland, Finland</i>	
11.1 Introduction .....	252
11.2 Milk fat synthesis .....	253
11.3 The need to change the fatty acid composition of milk fat ...	257
11.4 Factors affecting milk fatty acid composition .....	260
11.5 Strategies for improving the fatty acid content of raw milk ..	263
11.6 Future trends .....	273
11.7 Acknowledgements .....	274
11.8 References .....	274
<b>12 Optimising goat's milk and cheese fatty acid composition</b> .....	281
<i>Y. Chilliard, J. Rouel, A. Ferlay and L. Bernard, INRA, France, P. Gaborit, K. Raynal-Ljutovac and A. Lauret, ITPLC, France, and C. Leroux, INRA, France</i>	
12.1 Introduction .....	281
12.2 Biochemical characteristics and origin of goat milk lipids ...	284
12.3 Effect of alpha-s1 casein genotype on milk fatty acid composition .....	290
12.4 Controlling milk fatty acid composition by animal diet .....	292

12.5	Effects of dairy technology on goat's cheese fatty acid composition .....	302
12.6	Animal diet, processing and sensory quality of dairy products .....	304
12.7	Conclusions .....	305
12.8	Acknowledgements .....	305
12.9	References .....	306
<b>13</b>	<b>Reducing fats in raw meat .....</b>	<b>313</b>
	<i>A. P. Moloney, Teagasc, Grange Research Centre, Ireland</i>	
13.1	Introduction .....	313
13.2	The fat content of meat .....	314
13.3	Breeding effects on the fat content and composition of meat .....	316
13.4	Dietary effects on the fat content and composition of meat ..	319
13.5	Strategies for improving the fat content and composition of meat .....	322
13.6	Implications for the food processor .....	325
13.7	Future trends .....	328
13.8	Sources of further information .....	330
13.9	References .....	330
<b>14</b>	<b>Producing low-fat meat products .....</b>	<b>336</b>
	<i>J. F. Kerry and J. P. Kerry, University College Cork, Ireland</i>	
14.1	Introduction .....	336
14.2	Nutritional and health-promoting properties of fats .....	338
14.3	Textural characteristics of meat products attributed to fat ....	340
14.4	The role of fat in flavour development in meat products ....	344
14.5	Warmed-over flavour .....	347
14.6	Meat proteins .....	347
14.7	Technologies utilised in fat reduction of processed meats ...	351
14.8	Processing technologies .....	359
14.9	Antioxidants .....	360
14.10	Packaging and storage .....	361
14.11	Current regulations and labelling guidelines of low-fat products .....	362
14.12	Meat culinary issues .....	364
14.13	Conclusions .....	366
14.14	References .....	367
<b>15</b>	<b>The use of fat replacers for weight loss and control .....</b>	<b>380</b>
	<i>J. M. Jones, College of St Catherine, Minnesota, USA and S. S. Jonnalagadda, Novartis Medical Nutrition, Minnesota, USA</i>	
15.1	Introduction .....	380
15.2	Fat replacers and their uses .....	381

15.3	Categories of fat replacers .....	382
15.4	Fat replacers and weight loss .....	383
15.5	Conclusion .....	386
15.6	References .....	387
<b>16</b>	<b>Testing novel fat replacers for weight control</b> .....	<b>391</b>
	<i>C. M. Logan, J. M. W. Wallace, P. J. Robson and M. B. E. Livingstone, University of Ulster, UK</i>	
16.1	Introduction .....	391
16.2	Short-term studies .....	392
16.3	Possible mode of action .....	400
16.4	Implications for product development and future trends .....	401
16.5	Other fat replacements used in the control of body weight .....	402
16.6	Summary and conclusions .....	403
16.7	Sources of further information .....	403
16.8	References .....	404
<b>Part III</b>	<b>Using polyunsaturated and other modified fatty acids in food products</b>	
<b>17</b>	<b>Developing products with modified fats</b> .....	<b>411</b>
	<i>E. Flöter and A. Bot, Unilever Research and Development Vlaardingen, The Netherlands</i>	
17.1	Introduction .....	411
17.2	Improving the sensory quality of modified fat products .....	414
17.3	Development of nutritionally improved products .....	422
17.4	Summary .....	425
17.5	References .....	426
<b>18</b>	<b>Using polyunsaturated fatty acids (PUFAs) as functional ingredients</b> .....	<b>428</b>
	<i>C. Jacobsen and M. Bruni Let, Danish Institute for Fisheries Research, Denmark</i>	
18.1	Introduction .....	428
18.2	Current problems in producing n-3 PUFA and using fish oils in food products .....	432
18.3	Improving the sensory quality and shelf-life of n-3 PUFA- enriched foods .....	436
18.4	Future trends .....	446
18.5	Sources of further information .....	447
18.6	References .....	448

<b>19</b>	<b>New marine sources of polyunsaturated fatty acids (PUFAs)</b> ..	454
	<i>T. A. B. Sanders, King's College London, UK and H. E. Theobald, British Nutrition Foundation, UK</i>	
19.1	Introduction .....	454
19.2	Microbial sources of PUFA .....	457
19.3	Production methods .....	460
19.4	Future trends .....	469
19.5	Sources of further information .....	470
19.6	References .....	470
<b>20</b>	<b>Producing polyunsaturated fatty acids (PUFAs) from plant sources</b> .....	472
	<i>J. A. Napier, Rothamsted Research, UK</i>	
20.1	Introduction .....	472
20.2	The role of long chain PUFAs (LC-PUFAs) in humans .....	473
20.3	Dietary sources of essential fatty acids (EFAs) and LC-PUFAs .....	475
20.4	LC-PUFA biosynthetic pathways .....	477
20.5	Genes, technologies and resources .....	479
20.6	The production of C <sub>20</sub> LC-PUFAs in transgenic plants .....	483
20.7	Towards the production of docosahexaenoic acid (DHA) ....	485
20.8	Conclusions .....	486
20.9	Acknowledgements .....	486
20.10	References .....	486
<b>21</b>	<b>Virtually <i>trans</i> free oils and modified fats</b> .....	490
	<i>G. van Duijn, E. E. Dumelin and E. A. Trautwein, Unilever Research and Development Vlaardingen, The Netherlands</i>	
21.1	Introduction .....	490
21.2	The formation of <i>trans</i> fatty acids during hydrogenation .....	493
21.3	Oil modification techniques to produce virtually <i>trans</i> -free hardstocks .....	499
21.4	The formation of <i>trans</i> fatty acids during high-temperature deodorisation .....	504
21.5	Future trends .....	505
21.6	References .....	506
<b>22</b>	<b>Novel fats for the future</b> .....	508
	<i>J. Skorve, K. J. Tronstad, H. V. Wergedahl, K. Berge, Haukeland University Hospital, Norway, J. Songstad, University of Bergen, Norway and R. K. Berge, Haukeland University Hospital, Norway</i>	
22.1	Introduction: the concept of modified fatty acids .....	508
22.2	Short historical background .....	509
22.3	Structure and properties of tetradecylthioacetic acid (TTA) ..	510
22.4	Properties of 3-thia fatty acids .....	510

22.5	Modified fatty acids and the metabolic syndrome .....	511
22.6	Health benefits for humans .....	517
22.7	Future trends .....	518
22.8	References .....	519
<i>Index</i> .....		525