Coffee: Production, Quality and Chemistry

Part I: Coffee Production

Chapter 1	Introduction to Coffee Plant and Genetics	3
	Thiago Ferreira, Joel Shuler, Rubens Guimarães	
	and Adriana Farah	
	1.1 Introduction	3
	1.2 The Genus Coffea	4
	1.3 Origin and Distribution of Subgenus	
	Coffea in Africa	6
	1.4 The Coffee Plant	10
	1.4.1 Root System	10
	1.4.2 Orthotropic and Plagiotropic Branches	12
	1.4.3 The Leaves	13
	1.4.4 Flowering	16
	1.4.5 The Fruit	17
	Acknowledgements	22
	References	22
Chapter 2	Coffee Growing and Post-harvest Processing Rubens José Guimarães, Flávio Meira Borém, Joel Shuler, Adriana Farah and João Carlos Peres Romero	26
	2.1 Introduction 2.2 Adaptation and Improvements of the Main	26
	Commercial Species	27

	2.3	The Basics of Coffee Plant Growth	28
		Coffee Plant Propagation Techniques	31
		Planting the Coffee Crop	39
		Crop Management	45
		Coffee Cultivation in Agroforestry Systems	50
		Coffea arabica L. Prunings	51
		Coffea canephora Pierre Prunings	55
		Pests, Diseases, and Nematodes in	
	(Coffee Cultivation	56
	2	2.10.1 Identification of Signs and	
		Symptoms in Plants for Accurate	
		Diagnosis	56
	2	2.10.2 Coffee Plant Pests	57
	2	2.10.3 Coffee Plant Diseases	60
	2	2.10.4 Coffee Plant Nematodes	64
		Coffee Harvesting: Manual Selective, Manual	
		Stripping, and Mechanical	65
		2.11.1 Manual Selective Harvest	66
		2.11.2 Manual Strip Picking	66
		2.11.3 Mechanized Harvesting	66
		Coffee Post-harvest Processing	71
		2.12.1 Winnowing and Coffee Separation	71
		2.12.2 The Dry Process Method – Natural	
		Coffee	73
		2.12.3 The Wet Processing Method	76
		2.12.4 The Wet-hulled Method	79
		2.12.5 Animal Processing	79
		Dry Milling	81
		Defects	81
	Refer	ences	83
Chapter 3		ling Strategies	89
	Olivei	iro Guerreiro-Filho and Mirian Perez Maluf	
	3.1	Introduction: Coffea Species	89
	3.2	Biological Aspects of Coffea arabica and	
	1	Coffea canephora	90
	3.3	Genetics Aspects Associated with Fruit	
		Development and Cup Quality	91
	3.4	The Importance of Germoplasm Collections	92
		3.4.1 Natural Genetic Variability of Coffee	
		Fruits and Seeds	93
		3.4.2 Use of Natural Genetic Resources in	
		Breeding for Quality	93
		3.4.3 Naturally Caffeine-free Mutant – a	
		Success Case of Wild-type Resource Use	95

.

	3.4.4 Selection of High-Oil Plants	95
	3.4.5 Genetic Diversity for Fat Components	96
	References	97
Chapter 4	Coffee Plant Biochemistry	100
Unapter 4	Hiroshi Ashihara, Tatsuhito Fujimura and Alan Crozier	100
	4.1 Introduction	100
	4.2 Carbohydrate Metabolism in Coffee	101
	4.3 Nitrogen Metabolism	106
	4.4 Biosynthesis and Catabolism of Caffeine	109
	4.4.1 The De Novo Biosynthetic Pathway	
	of Caffeine	109
	4.4.2 Caffeine Biosynthesis from Purine	
	Nucleotides	111
	4.4.3 N-Methyltransferases Involved in	
	Caffeine Biosynthesis in Coffee Plants	113
	4.4.4 Metabolism of Caffeine in Coffea Plants	119
	4.4.5 Occurrence of Caffeine in <i>Coffea</i> Plants	122
	4.4.6 Physiological Aspects of Caffeine	
	Metabolism in Coffea Plants	125
	4.5 Biosynthesis of Trigonelline	130
	4.5.1 The De Novo Biosynthetic Pathway	
	of Trigonelline	130
	4.5.2 Pyridine Nucleotide Cycle for Nicotinic	
	Acid Formation in C. arabica	130
	4.5.3 Direct Formation of Nicotinic Acid	
	from NaMN	133
	4.5.4 Trigonelline Biosynthesis from	
	Nicotinic Acid	134
	4.5.5 Metabolism of Trigonelline in Coffea	
	Plants	134
	4.5.6 Occurrence of Trigonelline in Coffea	
	Plants	135
	4.5.7 Physiological Aspects of Trigonelline	
	Metabolism in <i>Coffea</i> Plants	135
	4.5.8 In Planta Function of Trigonelline in	
	Coffea Plants	139
	4.6 Biosynthesis of Chlorogenic Acids	139
	4.6.1 Biosynthetic Pathways of Chlorogenic	
	Acids	141
	4.6.2 Enzymes Involved in the Caffeoylquinic	
	Acids Biosynthesis in <i>Coffea</i> Plants	143
	4.6.3 Shikimic Acid Pathway in Plants	145
	4.6.4 Metabolism of Chlorogenic Acids in	
	Coffea Plants	147

ix

	4.6.5 Occurrence of Chlorogenic Acids in	
	Coffea Plants	147
	4.6.6 Physiological Aspects of Chlorogenic	
	Acid Biosynthesis in Coffea Plants	150
	4.6.7 In Planta Function of Chlorogenic	
	Acids in <i>Coffea</i> Plants	155
	4.7 Conclusions	155
	Acknowledgements	156
	References	156
Chapter 5	Mineral Nutrition and Fertilization	163
	H. E. P. Martinez, J. C. L. Neves, V. H. Alvarez V.	
	and J. Shuler	
	5.1 Introduction	163
	5.2 Nutrient Accumulation and Exportation	164
	5.3 Dynamic of Mineral Accumulation in	
	Flowers and Fruits	167
	5.4 Macronutrients, Micronutrients, and	
	Beneficial and Toxic Elements: Their	
	Effect on Coffee Plant Growth, Production,	
	and the Quality of its Beans	170
	5.4.1 Nitrogen, Phosphorus, and Potassium	170
	5.4.2 Calcium, Magnesium, and Sulfur	173
	5.4.3 Micronutrients	174
	5.4.4 Silicon	177
	5.4.5 Aluminum	177
	5.5 Diagnosis of Nutritional Status	178
	5.5.1 Visual Diagnosis	179
	5.5.2 Diagnosis Based on Tissue Analysis	179
	5.6 Soil Requirements for Coffee Plant	191
	5.6.1 Physical Characteristics	191
	5.6.2 Chemical Characteristics	192
	5.7 Liming 5.8 Gypsum Use	194
	5.9 Fertilization	195 196
	5.9.1 Crop Settlement 5.9.2 Crop Formation	196
	5.9.3 Crop Production	196 197
	5.9.4 Fertilization with Micronutrients	197
	References	197
Chapter 6	Coffee Grading and Marketing	202
	Carlos Henrique Jorge Brando	202
	6.1 Introduction	202
	6.2 Cleaning	203

	6.3 Separation by Size	203
	6.4 Separation of Defects	205
	6.5 Examples of Grading Systems	206
	6.5.1 Brazil/New York Method	206
	6.5.2 Kenyan Grading and Classification	207
	6.5.3 Specialty Coffee Association	
	(SCA) Green Coffee Classification	207
	6.6 Grading and Quality	210
	6.7 Other Dimensions of Grading	211
	Reference	212
Chapter 7	Decaffeination and Irradiation Processes in Coffee	
	Production	213
	Pedro F. Lisboa, Carla Rodrigues, Pedro C. Simões	
	and Cláudia Figueira	
	7.1 Introduction	213
	7.2 Decaffeination	215
	7.2.1 Decaffeination Process Using Organic	
	Solvents	217
	7.2.2 Natural Processes: Water or Swiss Water	
	Decaffeination	217
	7.2.3 Natural Process Using Supercritical CO ₂	218
	7.2.4 Chemical Differences and Health	
	Effects	220
	7.3 Irradiation	222
	7.4 Conclusions	226
	References	226
Chapter 8	Roasting	230
	Fernando Fernandes	
	8.1 Introduction	230
	8.2 Chemical and Physical Transformations	
	During Coffee Roasting	231
	8.2.1 Drying Process (up to 150 °C)	232
	8.2.2 Roasting Initial Stage (150 °C–180 °C)	233
	8.2.3 Roasting - Stage 2 (180 °C-230 °C)	233
	8.2.4 Roasting – Stage 3 (Above 230 °C)	236
	8.3 Heat Transfer Systems and Types of Industrial	
	Roasters	237
	8.3.1 A Brief History of Industrial Roasters	
	Evolution	238
	8.3.2 Positive Aspects of Convection for the	
	Coffee Roasting Process	247
	8.4 In Roasting Profile, Control of Coffee Bean	
	Temperature Is the Key	248

	8.4.1 Hot Air Temperature, Hot Air Flow,	
	Heat Transfer	248
	8.4.2 Bean Temperature Is What Roasting	
	Is All About	250
	8.5 Environmental Aspects in Coffee Roasting	251
	References	255
Chapter 9	Post-roasting Processing: Grinding, Packaging	
-	and Storage	258
	Carla Rodrigues, Filipe Correia, Tiago Mendes,	
	Jesus Medina and Cláudia Figueira	
	9.1 Introduction	258
	9.2 Grinding	260
	9.2.1 Particle Size	260
	9.2.2 Grinding Equipment	262
	9.2.3 Roasted and Ground Beans Degassing	263
	9.2.4 Ground Coffee Oxidation	264
	9.3 Packaging	264
	9.3.1 Packaging Materials and Techniques	264
	9.4 Storage	267
	9.5 Conclusions	269
	References	269
Chapter 10	Beverage Preparation	272
Chapter 10	M. P. De Peña, I. A. Ludwig and C. Cid	212
	M. I. De I thu, I. A. Dauwig und O. Olu	
	10.1 Introduction	272
	10.1 Introduction 10.2 Coffee Brewing Methodology	272 273
	10.1 Introduction10.2 Coffee Brewing Methodology10.2.1 Boiled Coffee	
	10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee	273
	10.2 Coffee Brewing Methodology	273 274
	10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee	273 274 275
	10.2 Coffee Brewing Methodology10.2.1 Boiled Coffee10.2.2 Turkish Coffee10.2.3 Vacuum Coffee	273 274 275 276
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 	273 274 275 276 276
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 	273 274 275 276 276 276
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 	273 274 275 276 276 276 276 277
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 	273 274 275 276 276 276 276 277 277
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 10.2.8 Mocha Coffee 	273 274 275 276 276 276 276 277 277 277
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 10.2.8 Mocha Coffee 10.2.9 Espresso Coffee 10.2.9 Espresso Coffee 10.3 Coffee Brewing Extraction 10.4 Coffee Brewing Quality 	273 274 275 276 276 276 276 277 277 277 277
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 10.2.8 Mocha Coffee 10.2.9 Espresso Coffee 10.2.9 Espresso Coffee 10.3 Coffee Brewing Extraction 10.4 Coffee Brewing Quality 10.5 Water Influence in Coffee Brewing 	273 274 275 276 276 276 277 277 277 277 278 278 278
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 10.2.8 Mocha Coffee 10.2.9 Espresso Coffee 10.2.9 Espresso Coffee 10.3 Coffee Brewing Extraction 10.4 Coffee Brewing Quality 10.5 Water Influence in Coffee Brewing 10.6 Physico-chemical Characteristics of 	273 274 275 276 276 276 277 277 277 277 278 278 278 279 280
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 10.2.8 Mocha Coffee 10.2.9 Espresso Coffee 10.2.9 Espresso Coffee 10.3 Coffee Brewing Extraction 10.4 Coffee Brewing Quality 10.5 Water Influence in Coffee Brewing 10.6 Physico-chemical Characteristics of Coffee Beverages 	273 274 275 276 276 276 277 277 277 278 279 280 281
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 10.2.8 Mocha Coffee 10.2.9 Espresso Coffee 10.2.9 Espresso Coffee 10.3 Coffee Brewing Extraction 10.4 Coffee Brewing Quality 10.5 Water Influence in Coffee Brewing 10.6 Physico-chemical Characteristics of Coffee Beverages 10.7 Caffeine Extraction 	273 274 275 276 276 276 277 277 277 277 278 278 278 279 280
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 10.2.8 Mocha Coffee 10.2.9 Espresso Coffee 10.2.9 Espresso Coffee 10.3 Coffee Brewing Extraction 10.4 Coffee Brewing Quality 10.5 Water Influence in Coffee Brewing 10.6 Physico-chemical Characteristics of Coffee Beverages 10.7 Caffeine Extraction 10.8 Phenolic Compounds and Non-phenolic 	273 274 275 276 276 276 277 277 277 278 278 278 279 280 281 282
	 10.2 Coffee Brewing Methodology 10.2.1 Boiled Coffee 10.2.2 Turkish Coffee 10.2.3 Vacuum Coffee 10.2.4 Plunger Coffee 10.2.5 Percolator Coffee 10.2.6 Filter Coffee/Drip Coffee 10.2.7 Napoletana Coffee 10.2.8 Mocha Coffee 10.2.9 Espresso Coffee 10.2.9 Espresso Coffee 10.3 Coffee Brewing Extraction 10.4 Coffee Brewing Quality 10.5 Water Influence in Coffee Brewing 10.6 Physico-chemical Characteristics of Coffee Beverages 10.7 Caffeine Extraction 	273 274 275 276 276 276 277 277 277 278 279 280 281

Contents

Contents		xiii
	10.10 Lipids (Diterpenes) Extraction	287
	10.11 Volatiles Extraction	288
	Acknowledgements	288
	References	288
Chapter 11	Instant Coffee Production Denisley G. Bassoli	292
	11.1 Introduction	292
	11.2 Current Uses	293
	11.3 Definition	294
	11.4 Production	294
	11.4.1 Green Coffee	294
	11.4.2 Roasting	295
	11.4.3 Grinding	296
	11.4.4 Extraction	296
	11.4.5 Extract Clarification	299
	11.4.6 Extract Concentration	299
	11.4.7 Aroma Recovery	300
	11.4.8 Drying	301
	11.4.9 Spray Drying	301
	11.4.10 Freeze Drying	304
	11.5 Packaging	305
	11.6 Decaffeination	305
	11.7 Trends	305
	References	306
Chapter 12		309
	M. D. del Castillo, B. Fernandez-Gomez,	
	N. Martinez-Saez, A. Iriondo-DeHond and	
	M. D. Mesa	
	12.1 Introduction	309
	12.2 Definition of Coffee By-products	311
	12.2.1 Pulp	311
	12.2.2 Mucilage	311
	12.2.3 Parchment	312
	12.2.4 Husks	312
	12.2.5 Silverskin	312
	12.2.6 Spent Coffee Grounds	313
	12.3 Chemical Composition of Coffee By-products	314
	12.3.1 Pulp	314
	12.3.2 Mucilage	316
	12.3.3 Parchment	316
	12.3.4 Husks	316
	12.3.5 Silverskin	316
	12.3.6 Spent Coffee Grounds	317

12.4 Applications of Coffee By-products	319
12.4.1 In Foods	319
12.4.2 In Health	322
12.4.3 Other Applications	324
12.5 Safety Concerns in the Use of Coffee	
By-products as a Natural Source of	
Compounds	327
12.6 Conclusions	328
Acknowledgements	329
References	329

Part II: Coffee Quality

Chapter 13	Coffee Cupping: Evaluation of Green Coffee Quality <i>Ildi Revi</i>	337
	13.1 Introduction – Overview of Cupping	337
	13.1.1 What is 'Coffee Cupping'?	338
	13.1.2 Why Does the Coffee Industry Cup?	339
	13.2 How to Cup Coffee	341
	13.2.1 Basic Cupping	342
	13.2.2 Materials: Environment, Equipment	
	and Supplies	343
	13.2.3 Skill: Performing the Protocols	
	and Etiquette	346
	13.2.4 Knowledge: Cupping Form	
	Terminology, Scoring and Lexicon	354
	13.2.5 Organization: Record-keeping	359
	13.3 Conclusion	359
	References	359
Chapter 14	Coffee - Sensory Aspects and Consumer Perception Rosires Deliza	361
	14.1 Introduction	361
	14.2 Extrinsic Factors Affecting Coffee Quality	
	Perception	362
	14.2.1 Product Packaging and Label	363
	14.3 Sensory Evaluation and Consumer	
	Studies. Methods Used in Sensory	
	Evaluation – a Coffee Industry Perspective	366
	14.3.1 Sensory Panel – Individuals Who	
	Perform a Sensory Test	368
	14.3.2 Consumer Panel	370
	14.4 Concluding Remarks	375
	References	376

Chapter 15	An Emotion Lexicon for the Coffee Drinking	
-	Experience	380
	K. Adhikari, E. Kenney, N. Bhumiratana and	
	E. Chambers IV	
	15.1 Introduction	380
	15.2 Why Study Food-evoked Emotions?	381
	15.2.1 Emotions and Their Origin	381
	15.2.2 Measuring Emotions	382
	15.3 An Emotion Lexicon for the Coffee Drinking	
	Experience (CDE)	382
	15.3.1 Developing the Initial Lexicon	382
	15.3.2 Refining the Initial Lexicon to Create	
	the Final Lexicon	383
3.2	15.3.3 A Further Insight into the Final Lexicon	384
	15.4 Conclusion	386
	References	386
Chapter 16	Influence of Genetics, Environmental Aspects and	
	Post-harvesting Processing on Coffee Cup Quality	387
	Flávio Meira Borém, Helena Maria Ramos Alves,	
	Diego Egídio Ribeiro, Gerson Silva Giomo, Margarete	
	Marin Lordelo Volpato, Rosângela Alves Tristão Borém	
	and José Henrique da Silva Taveira	
	16.1 Introduction	387
	16.2 Environment and Coffee Quality	388
	16.2.1 Climatic Suitability and Coffee Quality	388
	16.2.2 Ecological and Socio-environmental	
	Benefits Associated with the Presence	
	of Vegetation in Areas Planted to Coffee	395
	16.3 Genotype and Coffee Quality	396
	16.3.1 The Case of Yellow Bourbon	400
	16.3.2 Beverage Quality of Rust Resistant	
	Cultivars	400
	16.4 Post-harvest Processing and Coffee Quality	401
	16.4.1 Brief History on Post-harvest Methods	
	Nomenclature and Proposal for a	
	New One	401
	16.4.2 Influence of Processing on Coffee	
	Quality	402
	16.5 Spatial Distribution and Relationship	
	Between Quality, Environment, Genotype,	
	and Processing: Case Study of Specialty Coffees	
	from the Mantiqueira de Minas Region, Brazil	404
	16.6 Concluding Remarks	411
	References	412

xv

xvi		Contents
Chapter 17	Coffee Certification	418
-	Carlos Henrique Jorge Brando	
	17.1 Introduction	418
	17.2 The Focus of Certification: Grower	
	or Consumer?	419
	17.3 Certification, Verification and Others	419
	17.4 Sustainability	420
	17.4.1 Niche and Mainstream Markets	423
	17.4.2 Benefits to Growers and the Role of	
	Government	423
	17.4.3 Labels or Not?	425
	17.4.4 Traceability	425
	17.4.5 Sustainable Coffee Content	425
	17.5 Origin	427
	17.6 Quality	427
	Reference	428

Part III: Coffee Chemistry

Section I: Natural Coffee Compounds and Derivatives

Chapter 18	Proteins of Coffee Beans: Recent Advances	431
	Paulo Mazzafera, Flávia Schimpl and Eduardo Kiyota	
	18.1 Introduction	431
	18.2 The 11S Seed Storage Protein of Coffee	434
	18.3 A Family of 11S Proteins in Coffea	435
	18.4 2S Protein in Coffea	435
	18.5 Peptides and Proteases	438
	18.6 Does Coffee Have Bioactive Proteins and	
	Peptides?	439
	18.7 Conclusion	440
	Acknowledgements	441
	References	441
Chapter 19	Polysaccharides and Other Carbohydrates Joana Simões, Ana S. P. Moreira, Cláudia P. Passos, Fernando M. Nunes, M. Rosário M. Domingues and Manuel A. Coimbra	445
	19.1 Introduction 19.2 Green Coffee Polysaccharides and Other	445
	Carbohydrates	446

	19.3 Roasting-induced Changes	447
	19.3.1 Structural Changes of Carbohydrates	448
	19.3.2 Differences in Thermal Stability of	
	Coffee Galactomannans and	
	Arabinogalactans	451
	19.3.3 Changes in Cell Walls and Extractability	
	of Coffee Polysaccharides	453
	19.4 Conclusions	455
	Acknowledgements	456
	References	456
Chapter 20	Lipids	458
	K. Speer and I. Kölling-Speer	
	20.1 Introduction	458
	20.2 Coffee Oil	459
	20.2.1 Total Oil Content	459
	20.3 Fatty Acids	460
	20.3.1 Total Fatty Acids and Fatty Acids in	
	Triacylglycerides	460
	20.3.2 Free Fatty Acids	461
	20.4 Diterpenes in the Lipid Fraction of Robusta	
	and Arabica Coffees	462
	20.4.1 Free Diterpenes	466
	20.4.2 Diterpene Fatty Acid Esters	468
	20.4.3 Synthesis of Diterpene Esters	469
	20.4.4 Other Diterpene Compounds	471
	20.4.5 Diterpenes in the Lipid Fraction of	
	Roasted Coffees	474
	20.4.6 Diterpenes in Coffee Beverages	476
	20.5 Sterols	481
	20.6 Tocopherols	485
	20.7 Coffee Wax	487
	20.7.1 Pyrolysis/GC-MS Experiments	494
	Acknowledgements	495
	References	496
Chapter 21	Minerals	505
	Carmen Marino Donangelo	
	21.1 Introduction	505
	21.2 Methods of Analysis	506
	21.3 Minerals in Green and Roasted Coffee	
	Beans	507
	21.3.1 Green Coffee	507
	21.3.2 Ground Roasted Coffee	508
	21.3.3 Instant Coffee	509

xvii

	21.4 Minerals in Coffee Beverages 21.5 Contribution of Coffee to Dietary Mineral	510
	Intake	512
	21.6 Conclusions	513
	References	514
Chapter 22	Organic Acids	517
	Adriana Farah and Ângela Galvan de Lima	
	22.1 Introduction	517
	22.2 Coffee Organic Acids	518
	22.2.1 Methods Used for Determination	
	of Acidity and Organic Acids Content	
	in Coffee	518
	22.3 Organic Acids in Green Coffee	524
	22.4 Organic Acids in Ground Roasted Coffees	525
	22.5 Organic Acids in Brewed and Soluble Coffees	528
	22.6 Contribution of Organic Acids to Perceived	504
	Acidity and Cup Quality	531
	22.7 Coffee Organic Acids and Health	533
	22.8 Concluding Remarks	535 536
	Acknowledgement References	536
	References	220
Chapter 23	Caffeine and Minor Methylxanthines in Coffee	543
-	Juliana de Paula Lima and Adriana Farah	
	23.1 Introduction	543
	23.2 Chemical Characterization of	
	Methylxanthines	544
	23.3 Analysis of Methylxanthines	546
	23.4 Contents of Caffeine and Minor	
	Methylxanthines in Coffee and Coffee	
	Products	548
	23.4.1 Content of Methylxanthines in	
	Regular Green Coffee	548
	23.4.2 Contents of Methylxanthines in	
	Regular Roasted Coffee	550
	23.4.3 Contents of Methylxanthines in	
	Coffee Brews	550
	23.4.4 Content of Methylxanthines in Decaffeinated and Low-Caffeine	
	Coffees	E E 4
	23.5 Concluding Remarks	554 559
	Acknowledgements	559
	References	559
		000

Contents		xix
Chapter 24	Chlorogenic Acids	565
	Marius Febi Matei, Lee Seung-Hun and	
	Nikolai Kuhnert	
	24.1 Introduction – Chlorogenic Acids and	
	Hydroxycinnamates	565
	24.2 Chlorogenic Acids and Derivatives: Analysis	
	and Structure Elucidation	569
	24.3 Chlorogenic Acids Derivatives in Food	
	Processing	574
	24.4 Intake of Chlorogenic Acids and Derivatives	578
	24.5 Final Considerations	579
	References	579
Chapter 25	Major Chlorogenic Acids' Contents and	
	Distribution in Coffees	584
	Adriana Farah and Juliana de Paula Lima	
	25.1 Chlorogenic Acids Characterization	584
	25.2 Chlorogenic Acids Content in Green	
	Coffee	585
	25.3 Chlorogenic Acids Content in Roasted	
	Coffee	595
	25.4 Contribution of Chlorogenic Acids to	
	Cup-quality	604
	25.5 Chlorogenic Acids Content in Coffee	60 F
	By-products	605
	25.6 Conclusions	606 606
	References	000
Chapter 26	Isoflavones, Lignans and Other Minor	
	Polyphenols	611
	Luciano Navarini, Silvia Colomban, Giovanni	
	Caprioli and Gianni Sagratini	
	26.1 Introduction	611
	26.2 Chemistry	613
	26.2.1 Isoflavones	613
	26.2.2 Lignans	615
	26.3 Methods of Analysis	617
	26.4 Isoflavones Content in Coffee	620
	26.5 Lignans Content in Coffee	622
	26.6 Other Flavonoids in Coffee	622 624
	26.7 Conclusions References	624
	References	025

xx			Contents
Chapter 27	-	elline and Derivatives a Farah, Thiago Ferreira and Ana	627
		na Vieira	
		Introduction and Chemical Aspects Analysis of Trigonelline and Derivatives	627
		in Coffee Content of Trigonelline in Green Coffee	628
		Seeds	630
	27.4	Contents of Trigonelline, Nicotinic Acid, and Other Derivatives in Roasted Coffee	
	27.5	Seeds Content of Trigonelline, Nicotinic Acid,	633
	27.6	and Other Derivatives in Coffee Brew Contribution of Trigonelline to Cup	637
		Quality	637
	27.7	Concluding Remarks	638
	Refere	ences	638
Chapter 28	Bioact	ive Amines	641
	Maria	Beatriz A. Gloria and Nicki J. Engeseth	
		Introduction	641
	28.2	Chemical Characteristics of Coffee Bioactive	
		Amines	642
		Synthesis of Bioactive Amines	643
		Functions of Bioactive Amines in Plants	643
	28.5	Methods for the Analysis of Bioactive Amines	647
	28.6	Bioactive Amines During Coffee Growth and	• • •
		Development	648
	28.7	Bioactive Amines in Green Coffee	649
		Influence of Post-harvest Processing on	
		Bioactive Amines in Coffee	652
	28.9	Influence of Bean Quality on Bioactive	
		Amines	653
	28.10	Influence of Coffee Roasting on Bioactive Amines	654
	00 11		654
	28.11	Other Factors Affecting Bioactive Amines in Coffee	655
	28.12	Bioactive Amines in Coffee Beverages	655
		Bioactive Amines as Markers of Coffee	000
		Quality	658
	28.14	Concluding Remarks	659
		owledgement	659
	Refere		659

Contents		xxi
Chapter 29	Melanoidins Ana S. P. Moreira, Joana Simões, Cláudia P. Passos, Fernando M. Nunes, M. Rosário M. Domingues and Manuel A. Coimbra	662
	29.1 Introduction 29.2 Strategies for Quantitation, Isolation, and	662
	Purification of Coffee Melanoidins 29.3 Structural Components of Coffee	663
	Melanoidins 29.4 Possible Formation Routes of Coffee Melanoidins 29.5 Biological Activities and Potential Health	664 667
	Impacts of Coffee Melanoidins	670
	29.6 Conclusions References	674 675
	Kerenees	075
Chapter 30	Acrylamide	679
	José O. Fernandes	
	30.1 Introduction	679
	30.2 Chemical Characteristics	680
	30.3 Historical and General Occurrence in Foods	680
	30.4 Mechanisms of Formation in Foods	682
	30.4.1 Formation in Coffee	683
	30.5 Occurrence and Factors Affecting the	
	Formation of Acrylamide in Coffees	685
	30.6 Contribution of Coffee for the Human	
	Intake of Acrylamide	687
	30.7 Mitigation Strategies for the Reduction of	
	Acrylamide in Coffees	688
	30.7.1 Mitigation Strategies Based on Reduction	000
	of Asparagine	689
	30.7.2 Mitigation Strategies Based on	007
	Alterations of the Roasting Processing	
	Conditions	691
	30.7.3 Mitigation Strategies Based on	071
	Removing or Trapping of Acrylamide	
	Already Formed	692
	30.8 Final Considerations	693
	References	694
Chapter 31	β-Carbolines	697
	Daniela A. C. Rodrigues and Susana Casal	
	31.1 Introduction	697
	31.2 Chemical Properties and Formation Routes	698
	-	

Contents	C	01	rt	e	n	ts
----------	---	----	----	---	---	----

	31.3 β-Carbolines and Tetrahydro-β-carbolines	
	in Beverages and Food	699
	31.4 Norharman and Harman β-Carbolines	
	in Coffee	701
	31.5 Analysis of β -Carbolines and Tetrahydro-	
	β-carbolines in Foods	702
	31.6 Conclusion	703
	References	704
Chapter 32	Polycyclic Aromatic Hydrocarbons	705
	Olga Viegas, Olívia Pinho and Isabel	
	M. P. L. V. O. Ferreira	
	32.1 Introduction	705
	32.2 Chemical Structures of PAHs	706
	32.3 PAHs Formation Mechanism	708
	32.4 PAHs Formation in Foods	708
	32.5 PAHs Formation During Coffee	
	Roasting	709
	32.6 Analytical Methods for PAHs Determination	711
	32.7 Analytical Methods for PAHs Determination	
	in Coffee	712
	32.8 Occurrence of PAHs in Coffee	713
	32.8.1 PAHs Formation under Controlled	
	Roasting Conditions	714
	32.8.2 PAHs Occurrence in Coffee Samples	
	from Commercial Brands	717
	32.8.3 PAHs Transfer to the Coffee Brew	721
	32.9 Conclusions	722
	References	723
Chapter 33	Coffee Volatile and Aroma Compounds - From the	
	Green Bean to the Cup	726
	Chahan Yeretzian, Sebastian Opitz, Samo Smrke	
	and Marco Wellinger	
	33.1 Introduction	726
	33.2 Coffee Aroma – From Seed to Cup	727
	33.3 The Sensory Experience of Coffee	728
	33.4 Dynamic Headspace Analysis of Green	
	Bean Volatile Compounds	733
	33.5 Roasted Coffee Aroma Compounds	736
	33.6 Analytical Techniques for Coffee Aroma	-
	Analysis	738
	33.6.1 Gas Chromatography	738
	33.6.2 Olfactometry – When the Human Nose Becomes a Detector	738
	NOSC DECOMES & DELECTOR	138

	33.7 Trends and New Developments in Coffee	
	Aroma Analysis	747
	33.7.1 Time-resolved Analytical Techniques	747
	33.7.2 Analysis of Aroma Formation During	
	Roasting	748
	33.7.3 Extraction Kinetics of Coffee Aroma	
	Compounds	751
	33.7.4 Moving Towards an Individualized	
	Aroma Science – In-mouth Coffee Aroma	752
	33.7.5 Predicting Sensory Profile From	
	Instrumental Measurements	757
	33.8 What Next?	758
	Acknowledgements	759
	References	759
Chapter 34	Phytochemicals From Coffea Leaves	771
	Maria Teresa Salles Trevisan, Ricardo Farias de	
	Almeida, Andrea Breuer and Robert W. Owen	
	34.1 Introduction	771
	34.2 Phytochemical Composition of Coffee Leaves	772
	34.2.1 Chlorogenic Acids	774
	34.2.2 Mangiferins	775
	34.2.3 Rutin	780
	34.2.4 Caffeine	781
	34.3 Conclusions	781
	References	782
	Section II: Incidental Contaminants	
Chapter 35	Mycotoxins	791
Chapter 35	Rebeca Cruz and Susana Casal	751
	35.1 Introduction	791
	35.2 Major Mycotoxins in Coffee	792
	35.2.1 General Features	792
	35.2.2 Ochratoxin A	794
	35.2.3 Aflatoxins	798

35.2.3 Atlatoxins	/98
35.2.4 Sterigmatocystin	799
35.3 Analysis of Mycotoxins in Coffee	
Products	799
35.3.1 Immunoassays	800
35.3.2 Chromatographic Analysis	800
35.4 Conclusions and Future Perspectives	801
Acknowledgements	801
References	801

XXIV	

Chapter 36 Pesticide Residues

Pesticide Residues	805
Sara C. Cunha and José O. Fernandes	
OC 4 Junto Juntices	005
36.1 Introduction	805
36.2 Pesticide Definition, Classification and	
Pesticide Use	806
36.2.1 Insecticides	807
36.2.2 Fungicides	812
36.2.3 Herbicides	813
36.3 Physicochemical Proprieties	814
36.4 Legislation	816
36.5 Analytical Methods for Pesticide Residues	
Determination	816
36.6 Pesticide Residues in Coffee Beans and Beverage	819
36.7 Final Considerations	820
References	820
x	823

Contents

Subject Index

Coffee: Consumption and Health Implications

Chapter 1	Coffee Consumption and Health Impacts: A Brief History of Changing Conceptions <i>Edward F. Fischer, Bart Victor, Daniel Robinson,</i> <i>Adriana Farah and Peter R. Martin</i>	1
	1.1 Introduction	1
	1.2 African Origins, Islamic Consumption, and	
	Spiritual Health (9th-15th Centuries)	2
	1.3 Coffee and Western Medicine in the 16th and	
	17th Centuries	3
	1.4 Coffee, Chemistry, and Caffeine in the	
	18th and 19th Centuries	5
	1.5 Nineteenth-century Moral Questions and	
	20th-century Science	9
	1.6 Beyond Caffeine: Coffee and Health in the	
	20th and 21st Centuries	11
	1.7 Concluding Remarks	13
	References	14
Chapter 2	Coffee Antioxidants in Chronic Diseases	20
	M. D. del Castillo, A. Iriondo-DeHond, B. Fernandez-Gomez,	
	N. Martinez-Saez, M. Rebollo-Hernanz, M. A. Martín-	
	Cabrejas and A. Farah	
	2.1 Introduction	20
	2.2 Effect of Natural Coffee Antioxidants in Chronic Diseases	24

0011101110		1411
	2.2.1 Phenolic Compounds	24
	2.2.2 Coffee Indigestible Polyphenols	30
	2.2.3 Alkaloids	32
	2.2.4 Diterpenes	35
	2.2.5 Vitamins	36
	2.2.6 Minerals	37
	2.3 Effect of Coffee Processing Antioxidants in	
	Chronic Diseases	39
	2.3.1 Non-volatile Compounds of	
	Roasted Coffee	39
	2.3.2 Volatile Compounds of Roasted Coffee	44
	2.4 Conclusions	46
	Acknowledgements	47
	References	47
Chapter 3	Anti-inflammatory Activity of Coffee	57
F	Daniel León, Sonia Medina, Julián Londoño-Londoño,	
	Claudio Jiménez-Cartagena, Federico Ferreres and	
	A. Gil-Izquierdo	
	3.1 Introduction	57
	3.2 Relationship Between Food and Inflammation	58
	3.3 Coffee Bioactive Compounds Related to	
	Its Anti-inflammatory Activity	59
	3.4 Inflammatory Markers and Coffee	64
	3.4.1 Interleukins, Cytokines, and Tumour	
	Necrosis Factor (TNF- α)	65
	3.4.2 Amyloid-associated Protein	65
	3.4.3 Adiponectin	65
	3.4.4 General Comments on Coffee Consumption	
	and Inflammation	66
	3.5 Conclusions and Final Considerations	67
	References	69
Chapter 4	DNA Protective Properties of Coffee:	
	From Cells to Humans	75
	H. Al-Serori, T. Setayesh, F. Ferk, M. Mišík, M. Waldherr,	
	A. Nersesyan and S. Knasmüller	
	4.1 Introduction	75
	4.1 Infoduction 4.2 Experimental Models	76
	4.3 DNA Protective Properties of Coffees	76
	4.3.1 In Vitro Results	77
	4.3.2 Results of Animal Experiments	77
	4.3.3 Results of Human Studies	80
	4.3.4 Which Molecular Mechanisms	00
	Account for the DNA-protective	
	Properties of Coffee?	83

XXV

	4.4 What are the Active Principles of Coffee?	84
	4.4.1 Caffeine	84
	4.4.2 Chlorogenic Acids	86
	4.4.3 Melanoidins	87
	4.4.4 N-methylpyridinium	87
	4.4.5 Coffee Specific Diterpenoids	88
	4.5 Impact of Coffee Consumption on Diseases	
	Which Are Causally Related to DNA Damage	89
	4.5.1 Cancer	90
	4.5.2 Neurodegenerative Disorders	91
	4.5.3 Fertility	91
	4.5.4 Impact of Coffee Consumption on	
	Mortality	91
	4.6 Conclusions and Knowledge Gaps	92
	Abbreviations	93
	References	93
Chapter 5	Preventive Effect of Coffee Against	
onuptor	Cardiovascular Diseases	105
	L. Bravo, R. Mateos and B. Sarriá	
	5.1 Introduction	105
	5.2 Coffee and Cardiovascular Diseases.	
	Findings from Epidemiological Studies	106
	5.3 Coffee Phytochemicals and	
	Cardiovascular Risk	113
	5.3.1 Caffeine	117
	5.3.2 Polyphenols	118
	5.3.3 Diterpenes	119
	5.3.4 Other Components	119
	5.4 Coffee and Cardiovascular Disease	
	Risk Factors	121
	5.4.1 Effects of Coffee Consumption on	
	Blood Lipids	121
	5.4.2 Effects of Coffee Consumption on	
	Endothelial Function, Inflammation,	
	and Atherosclerosis. Mechanisms	
	of Action	126
	5.4.3 Effects of Coffee Consumption on	
	Plasma Homocysteine Levels	131
	5.4.4 Effects of Coffee Consumption on	
	Blood Pressure	133
	5.5 Concluding Remarks	137
	References	138

Contents	;
----------	---

Chapter 6	Coffee in the Development, Progression and Management of Type 2 Diabetes Heidi Virtanen, Rogerio Nogueira Soares and Jane Shearer	147
	6.1 Introduction	147
	6.1.1 Coffee and Type 2 Diabetes Risk	148
	6.1.2 Coffee and Diabetes Progression	152
	6.1.3 Coffee and Diabetes Management	152
	6.2 Mechanistic Insights	153
	6.2.1 Observational Data	154
	6.2.2 Clinical, Biochemical and Molecular Data	155
	6.3 Coffee-Caffeine Paradox	158
	6.4 Conclusion	159
	Abbreviations	159
	Acknowledgements	159
	References	159
Chapter 7	Caffeine and Parkinson's Disease: From Molecular Targets to Epidemiology and Clinical Trials Jiang-Fan Chen	171
	7.1 Introduction	171
	7.2 Pharmacological Targets of Caffeine Actions	173
	7.2.1 Non-adenosine Receptors	173
	7.2.2 Adenosine Receptors	173
	7.3 Caffeine and PD	174
	7.3.1 Potential Disease Modifying Effect of	
	Caffeine in PD	175
	7.3.2 Motor Benefit of Caffeine in PD	177
	7.3.3 Non-motor Effect of Caffeine in PD	179
	7.4 Implication of Widespread Caffeine Use	181
	7.5 Concluding Remarks	182
	References	184
Chapter 8	Coffee and Alzheimer's Disease	196
-	David Blum, Adriana Farah and Luisa V. Lopes	
	8.1 Introduction: Alzheimer's Disease	196
	8.2 Caffeine as a Cognitive Normalizer in AD	197
	8.3 Caffeine, Adenosine Receptor and AD Lesions	199
	8.4 Other Coffee Components and AD	201
	8.5 Conclusion	203
	Acknowledgements	203
	References	203

Chapter 9	Hepatoprotective Effect of Coffee	211
-	Erika Ramos-Tovar and Pablo Muriel	
	9.1 The Liver	211
	9.1.1 Liver Diseases Epidemiology	212
	9.1.2 Pathogenesis of Liver Fibrosis	214
	9.1.3 Oxidative Stress Strongly Participates	
	in the Pathogenesis of Liver Diseases	216
	9.1.4 Antioxidants to Fight Liver Diseases	216
	9.2 Antioxidant Properties of Coffee	217
	9.3 Coffee Consumption and Health	218
	9.4 Coffee Consumption and Liver Damage	219
	9.4.1 Clinical Evidence of Coffee Prevention	
	of Liver Disease	219
	9.4.2 Coffee Intake is Associated to	
	Several Beneficial Effects on Liver Fibrosis	220
	9.4.3 Effect of Coffee Consumption on	
	Hepatitis C Virus Infection	224
	9.4.4 Effect of Coffee Consumption on	
	Liver Cancer	224
	9.5 Conclusion and Perspectives	226
	Acknowledgements	227
	References	227
Chapter 10	Antimicrobial Activity of Coffee	234
Chapter 10	Maria Beatriz Abreu Glória, Ana Amelia Paolucci	234
	Almeida and Nicki Engeseth	
	Amena ana Moki Ingesen	
	10.1 Introduction	234
	10.2 Compounds Responsible for the	
	Antimicrobial Activity of Coffee	235
	10.2.1 Caffeine	235
	10.2.2 Trigonelline	237
	10.2.3 Phenolic Acids and Derivatives	237
	10.2.4 Other Natural Coffee Chemical	
	Compounds	239
	10.2.5 Compounds Generated During	
	Coffee Roasting	239
	10.3 Factors Affecting the Antibacterial	
	Activity of Coffee	242
	10.3.1 Coffee Variety and Species	242
	10.3.2 Roasting Status	242
	10.3.3 Coffee Decaffeination	243
	10.3.4 Brewing and Type of Coffee	243
	10.3.5 Coffee Concentration	244

w	1 2
~~	IX

	10.3.6 Types of Bacteria	244
	10.4 Antifungal Activity of Coffee	247
	10.5 Antiviral Activity of Coffee	249
	10.6 Antimicrobial Activity of Coffee	
	By-products	249
	10.7 Antimicrobial Properties of Coffee and	
	Health Benefits	250
	10.8 Concluding Remarks	251
	References	252
Chapter 11	Effect of Coffee on Oral Bacteria Involved in	
	Dental Caries and Periodontal Disease	255
	Tatiana Kelly da Silva Fidalgo, Andréa Fonseca-Gonçalves,	
	Daniel Cohen Goldemberg and Lucianne	
2	Cople Maia	
	11.1 Introduction	255
	11.2 Coffee and Its Components with	
	Antibacterial Activity Against Bacteria	
	Related to Systemic and Oral Diseases	256
	11.3 Antibacterial Action Mechanisms of	
	Coffee Extracts	257
	11.4 Effects of Coffee on Oral Bacteria	
	Involved in Caries Disease	258
	11.5 Effects of Coffee Extract on Oral	
	Bacteria Involved in Periodontal Disease	259
	11.6 Conclusion	261
	References	261
Chapter 12	Effect of Coffee on Weight Management	265
	S. Lafay and A. Gil-Izquierdo	
	12.1 Introduction	265
	12.2 Coffee Effect on Weight Management:	
	Epidemiological Studies	266
	12.3 Coffee Effect on Weight Management:	
	Caffeine and Coffee	267
	12.3.1 Caffeine	267
	12.3.2 Coffee	269
	12.4 Chlorogenic Acids and Decaffeinated Coffee	271
	12.5 Bioavailability of Caffeine and	
	Chlorogenic Acids	275
	12.6 Coffee and Microbiota Impact	278
	12.7 Conclusion	279
	References	280

Contents

Chapter 13	Potential Prebiotic Effect of Coffee	286
	Amanda Luísa Sales, Marco Antônio Lemos	
	Miguel and Adriana Farah	
	13.1 Introduction	286
	13.2 The Role of Intestinal Microbiota and	
	Probiotics in Human Health	288
	13.2.1 Human Microbiota and Microbiome	288
	13.2.2 The Complexity and Influence of	
	Human Gut Microbiome on Health	289
	13.3 Prebiotic Compounds and Their Benefit	
	to Health	292
	13.4 Coffee as a Source of Candidate	
	Prebiotic Compounds	293
	13.4.1 Potential Prebiotic Effects of	
	Coffee Soluble Fibers	294
	13.4.2 Potential Prebiotic Effects of	
	Coffee Melanoidins	296
	13.4.3 Potential Prebiotic Effects of	
	Chlorogenic Acids	298
	13.5 Potential Prebiotic Effect of Whole Coffee Brew	299
	13.6 Potential Prebiotic Effects of Coffee By-products:	
	Silverskin and Spent Grounds	300
	13.6.1 Coffee Silverskin	300
	13.6.2 Spent Coffee Ground	302
	13.7 Final Considerations	303
	Acknowledgements	305
	References	305
Chapter 14	Caffeine Consumption	313
	Juliana de Paula Lima and Adriana Farah	
	14.1 Introduction	313
	14.2 Caffeine Contents in the Most Consumed	515
	Stimulating Foods and Beverages	314
	14.2.1 Coffee	314
	14.2.2 Camelia Sinensis Teas	315
	14.2.3 Cocoa	315
	14.2.4 Maté	316
	14.2.5 Other Foods	316
	14.3 Global Caffeine Intake Estimates	317
	14.4 Safety on Caffeine Consumption and	
	Recommendations	320
	14.5 Labelling and Regulations on the	
	Addition of Caffeine in Beverages	332
	14.6 Final Considerations	333
	Acknowledgements	334
	References	334

Contents		xxxi
Chapter 15	Caffeine Metabolism and Health Effects	340
	Juliana de Paula Lima and Adriana Farah	
	15.1 Introduction	340
	15.2 Absorption	341
	15.3 Metabolism and Distribution	342
	15.4 Excretion	350
	15.5 Metabolism of Theobromine and	550
	Theophylline	351
	15.6 Caffeine and Health	353
	15.7 Toxicology of Caffeine and Minor	000
	Methylxanthines	354
	15.8 Concluding Remarks	355
	Acknowledgement	356
	References	356
Chapter 16	Chlorogenic Acids: Daily Consumption Through Coffee,	
	Metabolism and Potential Health Effects	364
	Adriana Farah and Juliana de Paula Lima	
	16.1 Introduction: Highlights on the Evolution	
	of Studies Involving Metabolism	
	of Coffee Chlorogenic Acids	364
	16.2 Chlorogenic Acids in Brewed and Instant	
	Coffees and Estimated Contribution to Daily	
	Consumption	366
	16.3 Metabolism of Chlorogenic Acids from Coffee	374
	16.3.1 Digestion	374
	16.3.2 Absorption, Liver Metabolism and	
	Plasma Appearance	375
	16.3.3 Metabolism by Intestinal Microbiota	380
	16.3.4 Urinary Excretion	381
	16.3.5 Excretion in Digestive Fluids	381
	16.4 Interaction Between Chlorogenic Acids and	
	Other Food Components: Effect on CGA	
	Bioaccessibility and Bioavailability	393
	16.5 Potential Health Effects of Chlorogenic Acids	
	and Their Lactones	394
	16.5.1 Antioxidant Activity	395
	16.5.2 Anti-inflammatory Effect and	
	Wound Healing	396
	16.5.3 Antimutagenic and Anticarcinogenic	
	Effects	397
	16.5.4 Hepatoprotective Effect	398
	16.5.5 Antidiabetic Effect	398
	16.5.6 Cardioprotective and	
	Antihypertensive Effects	399

	16.5.7 Antiobesity and Anti-metabolic	
	Syndrome Effects	399
	16.5.8 Neuroprotective Effects	400
	16.5.9 Antimicrobial Effect	401
	16.5.10 Potential Prebiotic Effect	402
	16.6 Concluding Remarks	403
	Acknowledgements	403
	References	403
Chapter 17	Potential Effects of Coffee Isoflavones and	
	Lignans on Health	416
	Luciano Navarini, Silvia Colomban,	
	Giovanni Caprioli and Gianni Sagratini	
	17.1 Introduction	416
	17.2 Coffee as a Dietary Source of	
	Isoflavones and Lignans	417
	17.3 Isoflavones, Lignans and Coffee	
	Estrogenic Activity	419
	17.4 Potential Contribution of Isoflavones and	
	Lignans to Chemoprevention by Coffee	421
	17.5 Potential Isoflavones and Lignans Contribution	
	to Coffee Anti-inflammatory Properties	424
	17.6 Isoflavones, Lignans and Other Coffee Benefits	425
	17.7 Hormetic Phytochemicals and	
	Concluding Remarks	425
	References	427
Chapter 18	Potential Effects of Trigonelline and	
	Derivatives on Health	432
	Ana Carolina Vieira Porto and Adriana Farah	
	18.1 Introduction	432
	18.2 Dietary Contribution	433
	18.3 Metabolism	434
	18.3.1 Trigonelline and N-Methylpyridinium	434
	18.3.2 Nicotinic Acid/Nicotinamide	436
	18.4 Toxicology	437
	18.5 Bioactivity	438
	18.5.1 Effects on Diabetes Mellitus Type 2 and Its	
	Complications	438
	18.5.2 Hypolipidemic Effect	440
	18.5.3 Antioxidant and Anti-tumorigenic Effects	443
	18.5.4 Antifibrotic and Hepatoprotective Effect	444
	18.5.5 Effects on the Central Nervous System	445

Contents

VVV	1	1	1	
7 7 7	1	L	1	

Contents		xxxiii
	18.5.6 Anti-thrombotic Effect	446
	18.5.7 Phytoestrogenic Effect	447
	18.5.8 Gastroprotective Effect	448
	18.5.9 Antimicrobial Effect	448
	18.6 Concluding Remarks	449
	References	450
Chapter 19	Potential Anti-carcinogenic Effects of	
•	Coffee Diterpenes	456
	G. J. E. J. Hooiveld and M. V. Boekschoten	
	19.1 Potential Anti-carcinogenic Effects of	
	Coffee Diterpenes	456
	References	458
Chapter 20	Potential Effects of β-Carbolines on	
onapter 10	Human Health	461
	Susana Casal	
	20.1 Introduction	461
	20.2 β -Carbolines Path in the Human Body	462
	20.2.1 Sources	462
	20.2.2 Bioavailability	463
	20.2.3 Metabolism	463
	20.3 Neuroprotective or Neurotoxic?	463
	20.4 Mutagenic or Antimutagenic?	465
	20.5 β -Carbolines as a New Potential Antidiabetic?	466
	20.6 Conclusion	466
	References	467
Chapter 21	Potential Effects of Coffee Melanoidins on Health	469
	S. Pastoriza and J. A. Rufián-Henares	
	21.1 Relationship Among Composition,	
	Physicochemical Properties and Health Effects	
	of Coffee Melanoidins	469
	21.2 Antioxidant Activity of Coffee Melanoidins	472
	21.3 Chelating Activity of Coffee Melanoidins	473
	21.4 Detoxifying Activity of Coffee Melanoidins	473
	21.5 Coffee Melanoidins as Modulators of the	
	Gut Microbiota	475
	21.6 Coffee Melanoidins as Antimicrobial Agents	476
	21.7 Conclusions	476
	Acknowledgement	476
	References	477

xxxiv
Char

Chapter 22	Potential Beneficial Effects of Bioactive	
	Amines on Health	479
	Maria Beatriz A. Gloria and Nicki J. Engeseth	
	22.1 Introduction	479
	22.2 Roles of Bioactive Amines in Human Health	480
	22.3 Metabolism of Bioactive Amines	481
	22.4 Potential Health Effects of	
	Bioactive Amines from Coffee	482
	22.4.1 Potential Health Effects Associated	
	with Indolamines	483
	22.4.2 Potential Health Effects Associated	
	with Agmatine	484
	22.4.3 Potential Health Effects Associated	105
	with Spermidine	485
	22.5 Concluding Remarks	485
	Acknowledgement	486
	References	486
Chapter 23	Potential Negative Effects of Caffeine	
-	Consumption on Health	489
	Juliana de Paula Lima and Adriana Farah	
	23.1 Introduction	489
	23.2 Potential Adverse Effects of Caffeine on Mood,	
	Behavior and Sleep	490
	23.3 Potential Adverse Effects of Caffeine on the	
	Cardiovascular System	491
	23.4 Potential Adverse Effects of Caffeine on	
	Glucose Metabolism and Insulin Resistance	494
	23.5 Potential Adverse Effects of Caffeine on	
	Calcium Balance	495
	23.6 Potential Adverse Effects of Caffeine on	
	Female Fertility and Reproductive and	
	Developmental Effects	497
	23.7 Potential Carcinogenicity of Caffeine	498
	23.8 Caffeine Withdrawal Syndrome	499
	23.9 Caffeine Acute Toxicity	500
	23.10 Concluding Remarks	501
	References	501
Chapter 24	Potential Detrimental Effects of Acrylamide on Health	509
	José Fernandes and Sara Cunha	
	24.1 Introduction	509
	24.1 Introduction 24.2 Acrylamide Toxicokinetics	510
	and nergiunne romeonnetteb	010

	24.3 Acrylamide Toxicity	512
	24.3.1 Neurotoxicity	512
	24.3.2 Reproductive and Developmental Toxicity	512
	24.3.3 Genotoxicity	513
	24.3.4 Carcinogenicity	514
	24.4 Mitigation of Acrylamide Toxicity	515
	24.5 Conclusions	516
	References	517
Chapter 25	Potential Effects of Furan and Related	
	Compounds on Health	520
	Isabel M. P. L. V. O. Ferreira, Olívia Pinho	
	and Catarina Petisca	
192	25.1 Introduction	520
	25.2 Furan and Related Compounds in	
	Heat-treated Foods	521
	25.2.1 Maillard Reactions	522
	25.2.2 Formation of Furan, HMF and	
	Furfural in Foods	523
	25.3 Occurrence of Furan, HMF and Furfural in Coffee	525
	25.3.1 Furan	525
	25.3.2 HMF	526
	25.3.3 Furfural	527
	25.4 Human Exposure	527
	25.4.1 Furan	527
	25.4.2 HMF	528
	25.4.3 Furfural	528
	25.5 Toxicity of Furan and Related Compounds	528
	25.5.1 Furan	528
	25.5.2 HMF	530
	25.5.3 Furfural	532
	25.6 Protective Effects of Furan and	
	Related Compounds	533
	25.7 Epidemiological Studies	534
	25.8 Conclusions	536
	References	536
Chapter 26	The Dyslipidemic Effect of Coffee Diterpenes	541
	M. V. Boekschoten and G. J. E. J. Hooiveld	
	26.1 Brewing Method Determines the	
	Association Between Coffee Consumption	
	and Cholesterol Levels	541
	26.2 Coffee Diterpenes are Responsible for the	
	Cholesterol-raising Effect of Some Coffee Types	542

XXXV

*

	26.3 Potential Mechanisms Underlying the Cholesterol-	
	raising Effect of Cafestol and Kahweol	543
	26.4 Health Implications of the Cholesterol-raising	
	Effect of Unfiltered Coffee	544
	References	545
Chapter 27	Potential Adverse Effects of Coffee Bioactive	
-	Amines to Human Health	548
	Maria Beatriz A. Gloria and Nicki J. Engeseth	
	27.1 Introduction	548
	27.2 Toxicological Aspects of Biogenic Amines	549
	27.2.1 Metabolism of Biogenic Amines	549
	27.2.2 Histamine and Tyramine Intoxication	549
	27.2.3 Toxicity Threshold and Legislation	551
	27.3 Biogenic Amines in Coffee Beverages	552
	27.4 Concluding Remarks	553
	Acknowledgements	554
	References	554
Chapter 28	Potential Mycotoxin Effects on	
	Coffee Consumers' Health	556
	Rebeca Cruz and Susana Casal	
	28.1 Introduction	556
	28.2 Ochratoxin A	558
	28.2.1 Toxicokinetics	558
	28.2.2 Toxicity	559
	28.2.3 Bioaccessibility and Bioavailability	560
	28.2.4 Coffee Protective Effects Against	
	Exposure to OTA	561
	28.2.5 The Effect of OTA Degradation	
	Products in Coffee Consumers	562
	28.3 Aflatoxin B_1	563
	28.3.1 Toxicokinetics and Toxicity	563
	28.3.2 Coffee Protective Effects Against	
	Exposure to AFB ₁	564
	28.4 Conclusions and Future Perspectives	564
	Acknowledgements	564
	References	565
Chapter 29	Carcinogenic Effects of Polycyclic Aromatic	
	Hydrocarbons and Modulation by Coffee Compounds	567
	Olga Viegas, Olívia Pinho and Isabel M. P. L. V. O. Ferreira	
	29.1 Introduction	567
	29.2 Toxicological Classification	569

Contenta		AAA VII
	29.3 Metabolism of PAHs	570
	29.4 Modulation of PAHs Metabolism by Coffee	572
	29.4.1 Modulation of PAHs Metabolism	
	by Caffeine	572
	29.4.2 Modulation of PAHs Metabolism	
	by Coffee Diterpenes	573
	29.4.3 Modulation of PAHs Metabolism	
	by Chlorogenic Acid	574
	29.5 Conclusions	575
	References	575
Chapter 30	Potential Effects of Pesticides Residues on Health	579
	Sara C. Cunha and José O. Fernandes	
5	30.1 Introduction	579
	30.2 Pesticide Toxicity	580
	30.2.1 Insecticides	580
	30.2.2 Fungicides	581
	30.2.3 Herbicides	581
	30.3 Effect of Processing and Dietary Intake Estimation	584
	30.4 Final Considerations	585
	References	585
Subject Inde	°X	587