

HANDBOOK OF

Analysis of Edible Animal By-Products

Considered high-priced delicacies or waste material to be tossed away, the use and value of offal—edible and inedible animal by-products—depend entirely on the culture and country in question. The skin, blood, bones, meat trimmings, fatty tissues, horns, hoofs, feet, skull, and entrails of butchered animals comprise a wide variety of products including human or pet food or processed materials in animal feed, fertilizer, or fuel. Regardless of the final product's destination, it is still necessary to employ the most up-to-date and effective tools to analyze these products for nutritional and sensory quality as well as safety.

Providing a full overview of the analytical tools currently available, the *Handbook of Analysis of Edible Animal By-Products* examines the role and use of the main techniques and methodologies used worldwide for the analysis of animal by-products. Divided into four parts, this unique handbook covers the chemistry and biochemistry involved in the fundamentals of the field and considers the technological quality, nutritional quality, and safety required to produce a viable product. Beginning with an introduction to the chemical and biochemical compounds of animal by-products, the book details the use and detection of food-grade proteins, rendered fats, and cholesterol. It discusses how to determine oxidation in edible by-products, measurement of color in these products, and the analysis of nutritional aspects such as essential amino acids, fatty acids, vitamins, minerals, and trace elements.

The latter portion of the book deals with safety parameters, particularly the analytical tools for the detection of pathogens, toxins, and chemical toxic compounds usually found in muscle foods. Specific chapters highlight the detection of tissues typically found in animal by-products, such as neuronal tissues, non-muscle tissues, and bone fragments.

K10202



www.crcpress.com

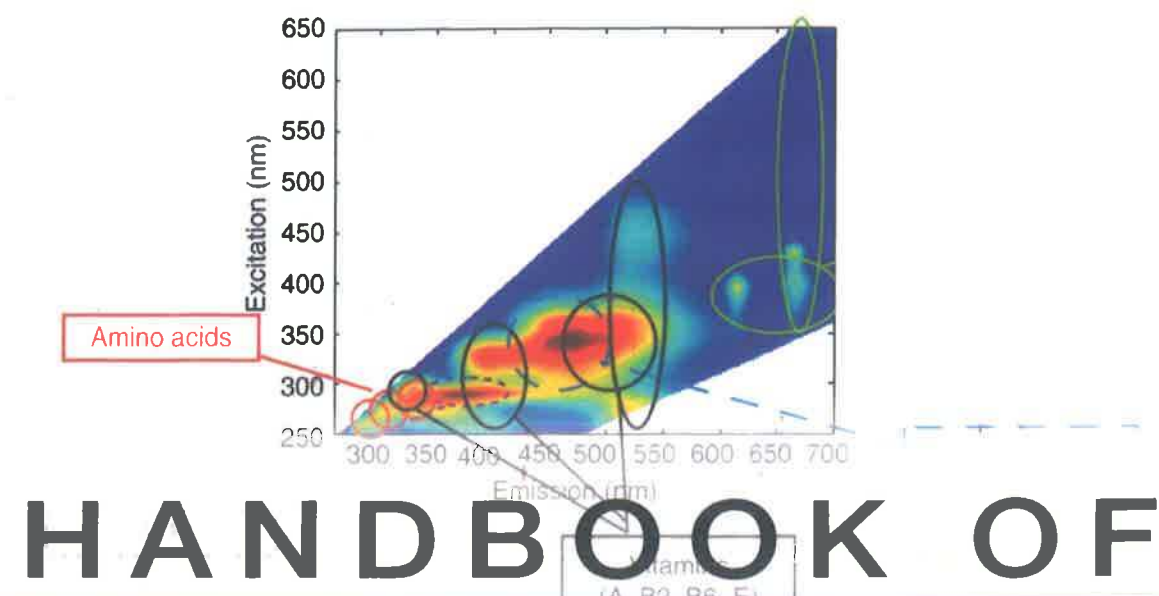
CRC Press
Taylor & Francis Group
an **informa** business
www.crcpress.com

6000 Broken Sound Parkway, NW
Suite 300, Boca Raton, FL 33487
270 Madison Avenue
New York, NY 10016
2 Park Square, Milton Park
Abingdon, Oxon OX14 4RN, UK

NOLLET
•
TOLDRA

HANDBOOK OF

Analysis of Edible Animal By-Products



HANDBOOK OF

Analysis of Edible Animal By-Products

Edited by
LEO M.L. NOLLET
FIDEL TOLDRA



CRC Press
Taylor & Francis Group

H A N D B O O K O F

Analysis of Edible Animal By-Products

Edited by
LEO M.L. NOLLET
FIDEL TOLDRÁ



CRC Press

Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **Informa** business

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

© 2011 by Taylor and Francis Group, LLC
CRC Press is an imprint of Taylor & Francis Group, an Informa business

No claim to original U.S. Government works

Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number: 978-1-4398-0360-8 (Hardback)

This book contains information obtained from authentic and highly regarded sources. Reasonable efforts have been made to publish reliable data and information, but the author and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The authors and publishers have attempted to trace the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission to publish in this form has not been obtained. If any copyright material has not been acknowledged please write and let us know so we may rectify in any future reprint.

Except as permitted under U.S. Copyright Law, no part of this book may be reprinted, reproduced, transmitted, or utilized in any form by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying, microfilming, and recording, or in any information storage or retrieval system, without written permission from the publishers.

For permission to photocopy or use material electronically from this work, please access www.copyright.com (<http://www.copyright.com/>) or contact the Copyright Clearance Center, Inc. (CCC), 222 Rosewood Drive, Danvers, MA 01923, 978-750-8400. CCC is a not-for-profit organization that provides licenses and registration for a variety of users. For organizations that have been granted a photocopy license by the CCC, a separate system of payment has been arranged.

Trademark Notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

Visit the Taylor & Francis Web site at
<http://www.taylorandfrancis.com>

and the CRC Press Web site at
<http://www.crcpress.com>

Contents

Preface.....	vii
Editors.....	ix
Contributors.....	xi

PART I Chemistry and Biochemistry

Chapter 1	Introduction—Offal Meat: Definitions, Regions, 'Cultures, and Generalities.....	3
	<i>Leo M.L. Nollet and Fidel Toldrá</i>	
Chapter 2	Food-Grade Proteins from Animal By-Products: Their Usage and Detection Methods.....	13
	<i>Yun-Hwa Peggy Hsieh and Jack Appiah Ofori</i>	
Chapter 3	Analysis of Rendered Fats.....	37
	<i>Stephen B. Smith and Dana R. Smith</i>	
Chapter 4	Analysis of Cholesterol in Edible Animal By-Products.....	43
	<i>Neura Bragagnolo</i>	
Chapter 5	Oxidation.....	65
	<i>Mario Estévez, Sonia Ventanas, Rui Ganhão, and David Morcuende</i>	

PART II Technological Quality

Chapter 6	Color Measurements on Edible Animal By-Products and Muscle-Based Foods.....	87
	<i>José Angel Pérez-Alvarez, María Estrella Sayas-Barberá, Esther Sendra Nadal, and Juana Fernández-López</i>	

PART III Nutritional Quality

Chapter 7	Composition and Calories.....	105
	<i>Karl-Otto Honikel</i>	
Chapter 8	Essential Amino Acids.....	123
	<i>María-Concepción Aristoy and Fidel Toldrá</i>	

Chapter 9	Fatty Acids	137
	<i>José A. Mestre Prates, Cristina Mateus Alfaia, Susana P. Alves, and Rui J. Branquinho Bessa</i>	
Chapter 10	Vitamins	161
	<i>Young-Nam Kim</i>	
Chapter 11	Minerals and Trace Elements	183
	<i>Guadalupe García-Llatas, Amparo Alegría, Reyes Barberá, and Rosaura Farré</i>	

PART IV Safety

Chapter 12	Spoilage Detection	207
	<i>Isabel Guerrero-Legarreta</i>	
Chapter 13	Microbial Foodborne Pathogens	219
	<i>Eleftherios H. Drosinos, Spiros Paramithiotis, and Nikolaos Andritsos</i>	
Chapter 14	Mycotoxins and Toxins	239
	<i>Carla Soler, José Miguel Soriano, and Jordi Mañes</i>	
Chapter 15	Detection of Bone in Meat	247
	<i>Wolfgang Branscheid and Michael Judas</i>	
Chapter 16	Detection of Adulterations: Identification of Animal Species	287
	<i>Johannes A. Lenstra and Stephan A. van der Heijden</i>	
Chapter 17	Detection of Neuronal Tissues and Other Non-Muscle Tissues with Respect to TSE	301
	<i>Ernst Lücker, Mitja Malunat, and Katharina Riehn</i>	
Chapter 18	Residues of Food Contact Materials	315
	<i>Emma L. Bradley and Laurence Castle</i>	
Chapter 19	Growth Promoters	335
	<i>Milagro Reig and Fidel Toldrá</i>	
Chapter 20	Antibiotics	355
	<i>Houda Berrada and Guillermina Font</i>	

Chapter 21	Environmental Contaminants: Pesticides	377
	<i>Pablo Vazquez-Roig and Yolanda Picó</i>	
Chapter 22	Environmental Contaminants: Heavy Metals	403
	<i>Giovanni Fortè and Beatrice Bocca</i>	
Chapter 23	Environmental Contaminants: Polychlorinated Biphenyls in Edible Animal By-Products	441
	<i>José A. Garcia-Regueiro and Massimo Castellari</i>	
Index		449

- Gajduskova, V. and Ulrich, R. (1992) Analysis of specific polychlorinated biphenyl congeners for the examination of raw-materials and foodstuffs of animal origin. *Veterinari Medicina* 37(8):471–478.
- Gallego-Iniest, A. M. and Peritierra-Rimada, E. (1987) Dieldrin transformation to photodieldrin in liver and kidney of Broiler. *Comparative Biochemistry and Physiology C, Comparative Pharmacology and Toxicology* 86(1):121–124.
- Garcia-Regueiro, J. A. and Castellari, M. (2009) Polychlorinated biphenyls: Environmental chemical contaminants in muscle food. In *Handbook of Processed Meats and Poultry Analysis*, L. M. L. Nollet and F. Toldrá, Eds. CRC Press, Boca Raton, FL, pp. 635–646.
- Goldstrand, R. E. (1988) Edible meat products: Their production and importance to the meat industry. In *Edible Meat By-Products* (Advances in Meat Research, Vol. 5), A. M. Pearson and T. R. Dutson, Eds. Elsevier Applied Science, Essex, U.K., p. 2.
- Hansen, L. G., Wilson, D. W., Metcalf, R. L., and Welborn, M. E. (1976) Residues of polychlorinated biphenyl (PCB) components in broiler cockerels receiving two aroclors in three dietary variations. *Journal of Agricultural and Food Chemistry*, 24(2):256–261.
- Hernandez, L. M., Gonzalez, M. J., Rico, M. C., Fernandez, M. A., and Aranda, A. (1988) Organochlorine and heavy metal residues in falconiforme and ciconiforme eggs (Spain). *Bulletin of Environmental Contamination and Toxicology* 40:86–93.
- Hernandez, L. M., Fernandez, M. A., and Gonzalez, M. J. (1989) Total PCBs and PCB congeners in Spanish imperial eagle eggs. *Bulletin of Environmental Contamination and Toxicology* 43:725–732.
- Jones, D., Safe, S., Morcom, E., Holcomb, M., and Coppockcivie, W. (1989) Bioavailability of grain and soil-borne tritiated 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD) administered to lactating Holstein cows. *Chemosphere* 18(1–6):1257–1263.
- Khalafalla, F. A., Awad, H. A., and Gergis, A. F. (1993) Organochlorine pesticide residues in meat and edible offals. *Veterinary Medical Journal Giza* 41(3):47–51.
- Klein, U., Drochner, W., Forschner, E., and Johannes, B. (1992) Concentrations of PCB in hair, blood, tissue and excretions of chronically contaminated cows, heifers and calf. 1. Course and relation of same polychlorinated-biphenyls in hair, milk and tissue of cows kept as nurse cows or in a tie-stall. *Deutsche Tierärztliche Wochenschrift* 99(6):242.
- Kofer, J. and Fuchs, K. (1994) Monitoring on residues in meat. 3. Pesticides in kidney fat. *Wiener Tierärztliche Monatsschrift* 81(2):33–36.
- Kurtz, D. A. and George, J. L. (1977) DDT metabolism in Pennsylvania white-tail deer. In *Fate of Pesticides in Large Animals*, G. W. Ivie and W. H. Dorrough, Eds. Academic Press, New York, pp. 193–216.
- Mataix Verdú, J. and Mañas Almendros, M. (1998) *Tabla de Composición de Alimentos Españoles* (Table of the Composition of Spanish Foods), 3rd edn. University of Granada, Granada, Spain.
- Mullins, M. D., Pochini, C. M., McCrindle, S., Romkes, M., Safe, S. H., and Safe, L. M. (1984) High-resolution PCB analysis: Synthesis and chromatography properties of all 209 PCB congeners. *Environmental Science & Technology* 18(6):468–476.
- Quick, M. P., Shaw, I. C., and Manser, P. A. (1989) A surprising case of endrin poisoning in dogs. *Journal of the Forensic Science Society* 29(5):331–338.
- Ratel, J. and Engel, E. (2009) Determination of benzenic and halogenated volatile organic compounds in animal-derived food by one-dimensional and comprehensive two-dimensional gas chromatography-mass spectrometry. *Journal of Chromatography A* 1216(45):7889–7898.
- Schramm, K.-W. (1997) Hair: A matrix for non-invasive biomonitoring of organic chemicals in mammals. *Bulletin of Environmental Contamination and Toxicology* 59:396–402.
- Schramm, K.-W. (2008) Hair-biomonitoring of organic pollutants. *Chemosphere* 72(8):1103–1111.
- Souci, S. W., Fachmann, W., and Kraut, H. (2008) *Food Composition and Nutrition Tables*, 7th edn. Taylor & Francis, Boca Raton, FL.
- Sundtröm, G., Hutzinger, O., Safe, S., and Platonow, N. (1977) The metabolism of p,p'-DDT and p,p'-DDE in the pig. In *Fate of Pesticides in Large Animals*, G. W. Ivie and W. H. Dorrough, Eds. Academic Press, New York, pp. 175–182.
- Ulrich, R. and Raszyk, J. (2002) Variations in environmental contamination by polychlorinated biphenyls (PCB) and chlorinated pesticides (Lindane, DDT) on pig farms in Hodonin district in 1994 to 1999. *Veterinari Medicina* 47(6):159–168.
- Van den Berg, M. et al. (1998) Toxic equivalence factors (TEFs) for PCBs, PCDDs, PCDFs for human and for wildlife. *Environmental Health Perspectives* 106(12):775.
- Van den Berg, M. et al. (2006) The 2005 World Health Organization re-evaluation of human and mammalian toxic equivalents factors for dioxins and dioxin-like compounds. *ToxSci Advance* (accessed on 7 July 2006).
- WHO-TEF (1998) http://www.who.int/ipcs/assessment/tef_update/en/

Index

A

- AAS, *see* Atomic absorption spectrometry
- ABA, *see* p-Aminobenzoic acid
- Active oxygen method (AOM), 70
- Adulterations
- breed identification, 293
 - dedicated method, 290–292
 - DNA barcoding, 293
 - multiplex PCR, 289, 293
 - PCR amplification, 289
 - DNA extraction, 288
 - DNA methodology, 287–288
 - ELISA and immunochemical methods, 287
 - isothermal amplification with electrochemical DNA detection, 289
 - microarrays, 289
 - mitochondrial DNA, 288–289
 - PCR-RFLP, 289
 - peptide biomarkers, 288
 - species identification, 287, 289
- Alkali hydrolysis, 163
- Alkyl mercury fungicides, 432
- American Oil Chemists' Society (AOCS), 69
- p-Aminobenzoic acid (ABA), 78
- Aminoglycosides
- antibiotics classification, 357
 - dihydrostreptomycin extraction, 370
 - LC-QqQ-MS method, 370
 - trichloroacetic acid, 370
- Aminoquinoline (AMQ), 130
- 6-Aminoquinolyl-n-hydroxysuccinimidyl carbamate (AQC), 130–131
- Amphenicols, 357
- Animal intestines, 212
- Anisotropic optical properties, 90
- Anodic stripping voltammetry (ASV), 422–423
- Antibiotics
- aminoglycosides, 370
 - analytical procedure, cost-effectiveness, 373
 - antimicrobial resistance, 355
 - β -lactams, 371
 - chemical structures, 358
 - European Union, 356
 - HPLC method, 373
 - identification points (IPs), 359
 - macrolides
 - chromatographic methods, 360–368
 - LC-DAD chromatograms, 369
 - SIM chromatograms, 369
 - multi-residue method, 373
 - nitrofurans, 370
 - quinolones, 371–372
 - semisynthetic, 355
 - tetracyclines, 372
 - veterinary drugs, 355

- Antioxidants, 163
- AOAC, *see* Association of Official Analytical Chemists
- AOM, *see* Active oxygen method
- APCI, *see* Atmospheric pressure chemical ionization
- Arsenic
- concentration, 426
 - fish and fishery products, 406
 - total diet studies, 405
 - wood preservation, 404
- Ascorbic acid, 175
- Association of Official Analytical Chemists (AOAC), 69
- Atmospheric pressure chemical ionization (APCI), 343
- Atomic absorption spectrometry (AAS), 419
- Atomic spectrometry
- applications, 195–197
 - Cd, Pb, and Zn concentrations, 194
 - DDTP-selenium complex, 194
 - FAAS and ICP-AES methods, 193
 - limitations, 194
 - SPE, 194
 - thermospray flame furnace atomic absorption spectrometer, 194

B

- Bacterial toxins, 243–244
- BDC, *see* Buoyant density gradient
- Biosensors, 231–232
- Biotin, 174–175
- BLG, *see* β -Lactoglobulin
- Bone detection, meat
- advanced meat recovery, 248
 - compact bones, 250
 - direct methods
 - bone marrow components, 254–255
 - bone particle content description, 260
 - bone particle histometry, 256
 - calcium analysis, 261
 - cartilage tissue, 255
 - chemical and histometrical determination, 259
 - chemical and physical isolation methods, 263–266
 - collagen fibers, 253–254
 - computer-aided video image analysis, 258
 - histomorphological gravimetric detection, 261–264
 - morphological and chemical isolation, 261
 - osteocytes morphology, 252–253
 - particle counting procedure, 256–257
 - point counting procedure, 257
 - radiologic detection, 266–270
 - staining methods, 255–256
 - indirect methods
 - bone marrow, 278
 - calcium and ash content analysis, 271–277
 - central nervous system, 278–279

- mechanically separated meat (*see* Mechanically separated meat)
 - trabecular bones, 250–251
 - Bovine serum albumin (BSA), 27, 29
 - Bovine spongiform encephalopathy (BSE), 17
 - Brain
 - BSE, 8
 - cholesterol, 48–49, 112, 145
 - conjugated linoleic acid
 - beef, 149
 - pork, 150
 - fatty acid content and composition
 - beef, 145–146
 - pork, 147–148
 - inedible by-products, 105
 - use, 279
 - vitamin D3, 211
 - Breed identification, 293
 - BSA, *see* Bovine serum albumin
 - BSE, *see* Bovine spongiform encephalopathy
 - Buoyant density gradient (BDC), 226
- C**
- Cadmium, 403
 - concentration
 - accumulations, 427, 429
 - edible animal by-products, 428
 - daily intake, 406–407
 - natural emissions, 406
 - Canadian food inspection agency (CFIA), 24
 - Carbamates, 380
 - Carotenoids, 163, 165
 - Caseinomacropptide (CMP), 30
 - CC, *see* Column chromatography
 - CC α , 359
 - CC β , 359
 - Central nervous system (CNS), 17
 - CFP, *see* Collagen-free protein
 - Channel electron multiplied arrays (CEMAS), 192
 - CHD, *see* Coronary heart diseases
 - Chemical migration
 - contact extent, foodstuff, 318
 - contact temperature, 318
 - contact time, 318
 - definition, 316–317
 - determinants, 316
 - extraction tests and migration levels estimation, 320
 - food simulants, 320–321
 - foodstuff, 318
 - impermeable materials, 317
 - migrating substance, 318
 - multilayer packaging materials, 317–318
 - overall migration and total extractables, 320
 - permeable materials, 317
 - porous materials, 317
 - residue for testing, 319
 - specific migration limits, 320
 - testing purpose, 319
 - Chemical oxygen demand (COD), 16
 - Chemometrics, 214–215
 - Cholesterol
 - animal cells, 44
 - blood levels, 43

- colorimetric and enzymatic analysis, 48
- contents
 - brain, 48–49
 - breed effect, 59
 - gizzard, 50
 - heart, 50–52
 - kidney, 50, 52–53
 - liver, 52, 54–56
 - lungs, 56–57
 - offal, 58–59
 - pancreas, 56–57
 - tongue, 57–58
- determination, 44
- GC analysis, 46–47
- HPLC analysis, 45–46
- LDL, 43
- metabolism, 44–45
- saponification and extraction, 45
- sterol, 44
- CLA, *see* Conjugated linoleic acid
- Clarithromycin, 357
- COD, *see* Chemical oxygen demand
- Coefficient of variation (CV), 22
- Collagen-free protein (CFP), 22
- Color measurement
 - CIELAB color coordinates, 90–91
 - color attributes
 - appearance, 88
 - categories, 87–88
 - quality parameter, 88–89
 - digital image analysis, 94
 - edible animal by-products
 - additives, 96–97
 - color and food engineering, 95–96
 - processing, 97–98
 - near infrared (NIR) technology, 93–94
 - optical properties, product, 90
 - photon migration techniques, 94–95
 - pigment extraction method, 90
 - reflectance measurement
 - adipose tissues, 91
 - chemical state and translucency, 93
 - dry-cured meat products, 91
 - isobestic point, 92
 - myoglobin, 91–92
 - rapid screening techniques, 92
 - reflecto-spectrophotometry, 92
 - spectral intensities, 92–93
 - visual assessment and instrumental color measurement, 92
- Column chromatography (CC), 389
- Composition and calories
 - bovine liver, 106–107
 - by-product and RDA values, 120
 - edible animal, 105–106
 - fatty acid groups and cholesterol, 112–113
 - losses of constituents, 110–112
 - mineral content, 112, 115–117
 - minerals and vitamins, 107–108
 - offal, 105
 - RDA, 110

- vitamin contents, 117–119
 - vs.* meat and animal by-products
 - bovine muscle, 108
 - cholesterol and fat content, 110
 - glycogen, 107
 - nutritional energy, 107–108
 - skeletal muscles, 107–108
 - Conjugated linoleic acid (CLA), 9
 - beef by-products, 149
 - ¹³C NMR spectroscopy, 145
 - diet, 151
 - fat nutritional quality, 153–154
 - gas chromatography, 144
 - pork by-products, 150
 - silver ion high-performance liquid chromatography, 144–145
 - Coronary heart diseases (CHD), 43
 - Culture-dependent methods
 - detection methods, 224
 - implementation, 220–221
 - most probable number, 223
 - plate count, 222–223
 - solid growth medium, 221
 - uses of, 220
 - Culture-independent methods
 - biosensors, 231–232
 - DNA-based detection
 - buoyant density gradient, 226
 - guanidine isothiocyanate, 226
 - immunomagnetic separation, 225
 - oligonucleotides, 227–228
 - pathogenic microbiota, 225
 - PCR-DGGE, 230
 - polymerase chain reaction, 224
 - single-strand conformation polymorphism, 230
 - immunological detection, 231
 - Cyanocobalamin, 173
- D**
- 4-Dimethyl-aminoazobenzene-4'-sulfonyl chloride, 128
 - 1-Dimethylamino-naphtalene-5-sulfonyl chloride, 128–129
 - 2,4-Dinitrophenyl (DNP), 75
 - Dinitrophenylhydrazine (DNPH), 66, 75
 - 5,5'-Dithio-bis-nitrobenzoic acid (DTNB), 130
 - 3,3'-Dithiodipropionic acid, 129
 - DNA barcoding, 293
 - DNPH, *see* Dinitrophenylhydrazine
 - Dry rendering method, 37
 - DTNB, *see* 5,5'-Dithio-bis-nitrobenzoic acid
- E**
- EFSA, *see* European Food Safety Authority
 - Electrospray ionization (ESI), 343
 - Enzymatic-photometric CNT detection, 304
 - Enzyme-linked immunosorbent assay (ELISA), 19, 306–307, 340
 - Essential amino acids
 - arginine/glutamine, 124
 - cysteine, 124
 - deproteinization, 127
 - edible by-products, 123, 125

- extraction, 127
- free amino acids, 126
- fresh liver, 123–124
- high-performance liquid chromatography
 - 6-aminoquinolyl-n-hydroxysuccinimidyl carbamate (AQC), 130–131
 - 4-dimethyl-aminoazobenzene-4'-sulfonyl chloride, 128
 - 1-dimethylamino-naphtalene-5-sulfonyl chloride, 128–129
 - gas-liquid chromatography, 132
 - ninhydrin, 128
 - o-phthalaldehyde (OPA), 129–130
 - phenylisothiocyanate (PITC), 128
 - separation and detection, 131–132
- hydrolysis, 126
- pork meat by-products, 125
- European Food Safety Authority (EFSA), 25, 404

F

- FAD, *see* Flavin adenine dinucleotide
- FAME, *see* Fatty acid methyl ester
- Fat-soluble vitamins
 - carotenoids, 163, 165
 - edible animal by-product, 162–163
 - vitamin A, 163, 165
 - vitamin D, 166–167
 - vitamin E, 167
 - vitamin K, 167–168
- Fatty acid methyl ester (FAME), 140–141
- Fatty acids
 - acidic catalysts, 139
 - animal-derived products, 138
 - base-catalyzed transesterification, 139
 - chloroform/methanol, 138
 - C NMR spectroscopy, 145
 - conjugated isomers of linoleic acid, 143
 - gas chromatography, 144
 - beef by-products, 139
 - FAME, 139–140
 - GC analyses, 140
 - GC-FID, 139
 - GC instrumentation, 141–142
 - lipids, 140
 - nonadecanoic acid, 141
 - pork by-products, 140
 - ruminant-derived fats, 139
 - tricosanoic acid, 141
- hyphenated techniques, 143
- lipid composition
 - arachidonic acid, 147
 - beef by-products, 145–146
 - docosapentaenoic acid, 148
 - FAME and CLA methyl ester profile analysis, 146
 - linoleic acid, 149–151
 - meat fatty acid composition, 147
 - methodology, 146
 - nonadecanoic acid, 147
 - pork by-products, 147
 - TFA, 148
- lipid extraction, 138
- methylene dichloride, 138
- nutritional quality

- arachidonic acid, 152
- conjugated isomers of linoleic acid, 153–154
- dietary n-3 PUFA, 152
- TFA, 152
- Western and Eastern diets, 152
- phospholipids, 138
- PUFA oxidation, 139
- silver ion chromatography, 142
- silver ion high-performance liquid chromatography, 144–145
- spectroscopy, 142–143
- ultra-performance liquid chromatography, 143
- Ferrous oxidationxylenol orange (FOX), 69
- FINS, *see* Forensically informative nucleotide sequencing
- Flame ionization detector (FID), 46
- Flavin adenine dinucleotide (FAD), 169
- Flavin mononucleotide (FMN), 169
- Fluorescence detection (FLD), 78
- Fluorescence polarization immunoassay (FPIA), 392
- Fluoroquinolones, 357
- Folate, 172–173
- Food and drug administration (FDA), 24
- Food contact materials
 - active and intelligent packaging, 331–332
 - cartonboard
 - packaging, 323–324
 - semivolatile migrant testing, benzophenone-GC-MS, 324–325
 - chemical migration
 - contact extent, foodstuff, 318
 - contact temperature, 318
 - contact time, 318
 - definition, 316–317
 - determinants, 316
 - extraction tests and migration levels
 - estimation, 320
 - food simulants, 320–321
 - foodstuff, 318
 - impermeable materials, 317
 - migrating substance, 318
 - multilayer packaging materials, 317–318
 - overall migration and total extractables, 320
 - permeable materials, 317
 - porous materials, 317
 - residue for testing, 319
 - specific migration limits, 320
 - testing purpose, 319
 - contamination, 316
 - food packaging materials, 316
 - glass bottle
 - fluorescent migrant testing, bisphenol A-HPLC-FLD, 326–327
 - packaging, 325–326
 - nanomaterials, 332–333
 - NIAS, 330–331
 - plastic pots
 - packaging, 321–322
 - volatile migrant testing, styrene-headspace-GC-MS, 322–328
 - sachet
 - decomposition product testing, colorimetric test and LC-UV or LC-MS, 328–329
 - packaging, 327–328
 - surface-active biocides, 332

- Food grade proteins
 - animal by-products, 13–14
 - blood and blood products
 - bovine blood, 17, 20
 - cellular fraction, 14
 - dietary restrictions, 17–18
 - food industry, 16
 - immunological methods, 19
 - Kjeldahl method, 18
 - LC-MS-MS, 19
 - plasma fraction, 14
 - plasma proteins, 16–17
 - sausage products, 16
 - spectrophotometric method, 18
 - collagen
 - autofluorescence spectroscopy, 22–23
 - CFP, 22
 - hydroxyproline, 22
 - manufacturing process, 21
 - meat products, 20
 - methods, 21
 - NIR, 22
 - preparations, 20
 - SDS-PAGE, 23
 - gelatin
 - acid/alkaline, 23–24
 - allergic reactions, 24–25
 - bovine/porcine, 25
 - ELISA method, 25
 - PCA, 26
 - PCR systems, 26
 - pig skins, 24
 - polyclonal antibodies, 25
 - uses, 24
 - whey and whey proteins
 - benefits, 29
 - categories, 26
 - CMP, 30
 - composition and pH, 26–27
 - ELISA, 30
 - hypoallergenic formulas, 30–31
 - k-casein, 30
 - soybean and bovine, 29
 - uses, 27–28
 - Food safety and inspection service (FSIS), 21
 - Forensically informative nucleotide sequencing (FINS), 293
 - Fourier transform infrared spectroscopy (FTIR), 72, 215
 - FOX, *see* Ferrous oxidationxylenol orange
 - FPIA, *see* Fluorescence polarization immunoassay
- G**
- Gas chromatography (GC), 45, 144, 337
 - beef by-products, 139
 - FAME, 139–140
 - GC analyses, 140
 - GC-FID, 139
 - GC instrumentation, 141–142
 - lipids, 140
 - nonadecanoic acid, 141
 - pesticides, 384–385
 - pork by-products, 140
 - ruminant-derived fats, 139
 - tricosanoic acid, 141

- Gas chromatography-mass spectrometry (GC-MS), 78, 308–310
- Gas-liquid chromatography, 132
- Gelatin manufacturers institute of america (GMIA), 24
- Gel permeation chromatography (GPC), 390
- Gizzard
 - chickens farmed, 430
 - cholesterol, 50
 - hydrolyzed chicken gizzard, 129–130
- GMIA, *see* Gelatin manufacturers institute of america
- GPC, *see* Gel permeation chromatography
- Growth promoters
 - antithyroidal agents, 337
 - β -agonists, 337
 - confirmatory analytical methods
 - ESI and APCI, 343
 - MS, 342–343
 - triple QqQ spectrometer, 343
 - control, 337–338
 - corticoids, 337
 - immunoaffinity chromatography, 340
 - molecular recognition, 340
 - residues, 335–336
 - sampling and sample extraction, 338–399
 - screening methods
 - biosensors, 341
 - chromatographic techniques, 341
 - immunological techniques, 340–341
 - sedatives, 337
 - solid-phase extraction procedures, 339–340
 - steroid hormones, 336
 - stilbenes, 336–337
- Guanidine isothiocyanate (GuSCN), 226

H

- Hanus method, 39
- Headspace solid phase micro extraction (HS-SPME), 389
- Heart, 50–52
- Heavy metals
 - acceptability criteria, 424–425
 - AMA-254 techniques, 420, 422
 - anodic stripping voltammetry, 422–423
 - arsenic
 - concentration, 426
 - sources and dietary intake, 404–406
 - ASV, 420, 422
 - cadmium
 - concentration, 426–429
 - sources and dietary intake, 403, 406–408
 - contamination control, 412
 - CV-AFS, 422
 - digestion procedures and quantification techniques, 413–416
 - dry ashing procedure, 417
 - F-AAS sensitivity, 421
 - GF-AAS analysis, 421
 - ICP-MS techniques, 421
 - lead
 - concentration, 430–432
 - sources and dietary intake, 408
 - longer-term Pb exposure, 404
 - measurement uncertainty, 425–426
 - mercury
 - concentration, 432–434
 - sources and dietary intake, 408–409
 - microwave digestion procedure, 417
 - neutron activation analysis, 422
 - regulations, advisory, and guidelines, 410–412
 - short term Pb exposure, 403
 - validation parameters
 - limit of detection, 423
 - linearity and robustness, 424
 - sensitivity and specificity, 423
 - trueness and precision determination, 424
 - wet digestion procedure, 417
- High-performance liquid chromatography (HPLC)
 - 6-aminoquinolyl-n-hydroxysuccinimidyl carbamate (AQC), 130–131
 - cholesterol analysis, 45–46
 - 4-dimethyl-aminoazobenzene-4'-sulfonyl chloride, 128
 - 1-dimethylamino-naphthalene-5-sulfonyl chloride, 128–129
 - fluxogram, 47
 - gas-liquid chromatography, 132
 - ninhydrin, 128
 - o-phthalaldehyde (OPA), 129–130
 - phenylisothiocyanate (PITC), 128
 - separation and detection, 131–132
- High-performance liquid chromatography-diode-array detector (HPLC-DAD), 78
- High-performance thin layer chromatography (HPTLC), 341
- Hypoallergenic formulas (HFs), 30

I

- Immunoglobulins (IgG), 27
- Immunomagnetic separation (IMS), 225
- Instrumental neutron activation analysis (INAA), 190
- Iron deficiency anemia (IDA), 17

K

- Kidney
 - beef and veal, 7
 - cholesterol, 50, 52–53
 - colorimetric methods, 50, 52
 - conjugated linoleic acid
 - beef, 149
 - pork, 150
 - fatty acid content and composition
 - beef, 145–146
 - pork, 147–148
 - nutrient content, 4
- Kloeckera brevis*, 171

L

- α -Lactalbumin (ALA), 27, 29
- β -Lactams
 - classification of antibiotics, 357
 - kidney tissue, 371
 - multi-residue analytical method, 371
- Lactobacillus plantarum*, 175
- β -Lactoglobulin (BLG), 27, 29
- Layer chromatography (LC), 337
- LDL, *see* Low density lipoprotein

- Lead, 408
 - concentration
 - accumulations, 431
 - edible animal by-products, 430
 - uses, 432
 - sources and dietary intake, 408
 - Limit of detection (LoD), 423
 - Lipid oxidation
 - mechanisms and factors, 67
 - primary oxidation changes, 67–70
 - secondary oxidation changes, 71–73
 - Liquid chromatography (LC), 390–391
 - Liquid chromatography tandem mass spectrometric (LC-MS-MS), 19
 - Liver
 - carbohydrates, 112
 - cholesterol, 52, 54–56
 - conjugated linoleic acid
 - beef, 149
 - pork, 150
 - consumption, 7
 - fat-soluble vitamins (*see* Fat-soluble vitamins)
 - fatty acid content and composition
 - beef, 145–146
 - pork, 147–148
 - nutrient content, 4
 - primary lipid oxidation changes, 68
 - secondary lipid oxidation changes, 71
 - vitamin contents, 117
 - water-soluble vitamins (*see* Water-soluble vitamins)
 - weight of by-products, 4
 - LoD, *see* Limit of detection
 - Low density lipoprotein (LDL), 43
 - L. rhamnosis*, 169
 - Lungs
 - cholesterol, 56–57
 - protein level, 209
 - sausages, 212
 - weight of by-products, 4
- M**
- MAB, *see* Monoclonal antibody
 - Macrolide antibiotics, 357
 - Malondialdehyde (MDA), 66
 - Mass spectrometry (MS), 45
 - Matrix solid phase dispersion (MSPD), 388
 - Maximum residue limit (MRL), 336
 - Meat and animal by-products
 - bovine muscle, 108
 - cholesterol and fat content, 110
 - glycogen, 107
 - nutritional energy, 107–108
 - skeletal muscles, 107–108
 - Mechanically separated meat
 - bone composition, 272–273
 - calcium content
 - analytical determination, 275
 - bone intercorrelations and ash, 277
 - fresh meat, 274
 - meat cuts and minced meat, 274
 - detection methods, 248
 - EU legislation, 249
 - MSM (I) and (II), 249

- properties of, 249
- USDA definition, 248
- Menaquinones, 167
- Mercury
 - concentration
 - accumulation, 434
 - alkyl mercury fungicides, 432
 - edible animal by-products, 433
 - daily intakes, 410
 - uses, 408
- Microarrays, 289
- Microbial foodborne pathogens
 - culture-dependent methods
 - detection methods, 224
 - implementation, 220–221
 - most probable number, 223
 - plate count, 222–223
 - solid growth medium, 221
 - uses of, 220
 - culture-independent methods
 - biosensors, 231–232
 - DNA-based detection, 224–230
 - immunological detection, 231
- Microwave digestion, 417
- Minerals
 - atomic spectrometry
 - applications, 195–197
 - Cd, Pb, and Zn concentrations, 194
 - DDTP-selenium complex, 194
 - FAAS and ICP-AES methods, 193
 - limitations, 194
 - SPE, 194
 - thermospray flame furnace atomic absorption spectrometer, 194
 - determination methods
 - certified reference materials, 189
 - electroanalysis, 190
 - FAAS method, 189–190
 - neutron activation analysis, 190–191
 - dry ashing, 188
 - ETAAS determination, 188
 - iron and zinc contents, 183–184
 - kidney and liver, 183
 - liver and kidney copper concentrations, 185–186
 - nutritional interest, 184
 - offal meats, 183
 - organic matter destruction-mineralization, 186
 - speciation, 198
 - wet ashing
 - acid leaching, 187
 - microwave digestion systems, 188
 - microwave energy, 187
 - nitric/hydrochloric acid concentration, 187
 - spectrofluorometry, 186–187
 - uses, 188
 - vapor-phase acid digestion procedure, 187
 - Zn determination, 187
- X-ray fluorescence
 - application techniques, 193
 - channel electron multiplied arrays, 192
 - determinations, 192–193
 - limitations, 192
- Molecular imprinted polymers (MIPs), 340
- Monoclonal antibody (MAB), 19

- Monounsaturated fatty acid group (MUFA), 112
 - MRL, *see* Maximum residue limit
 - MS, *see* Mass spectrometry
 - MSPD, *see* Matrix solid phase dispersion
 - MUFA, *see* Monounsaturated fatty acid group
 - Mycotoxins
 - cleanup procedures, 240–241
 - laboratory precautions, 240
 - OTA, 230, 239
 - pre-concentration, 240–241
 - quantitative methods and detection systems, 241–243
 - sample preparation, 240–241
 - screening tests, 241
 - Myoglobin, 91
- N**
- Natural colorant, 89
 - Near infrared reflectance (NIR), 22
 - Neuronal and non-muscle tissues detection
 - bovine animals, 301
 - ELISA, 306–307
 - enzymatic-photometric CNT detection, 304
 - GC/MS, 308–310
 - microscopy and immunohistology, 307
 - PCR, 307–308
 - SRM, 301
 - Western blot, 304–306
 - Neutron activation analysis (NAA), 422
 - PC-INAA-AC method, 191
 - selenium, 191
 - standard reference material, 191–192
 - Niacin (vitamin B₃), 170–171
 - NIR, *see* Near infrared reflectance
 - Nitrofurans
 - antibiotic analysis, 370
 - classification of antibiotics, 357
 - 2-Nitro-5-thiobenzoate (NTB), 78
 - N*-methyl-*N*-(*t*-butyldimethylsilyl)trifluoroacetamide (MTBSTFA), 132
 - Nonadecanoic acid, 147
 - Non-intentionally added substances (NIASs), 330–331
- O**
- Ochratoxin A (OTA)
 - CRM chromatogram, 244
 - extraction of, 240
 - nonruminant animals, 239
 - quantitative methods and detection systems, 241–243
 - ruminant animals, 239
 - structure of, 240
 - Offal meat
 - edible animal by-products
 - blood, 8–9
 - brains and testicles, 8
 - caltabos, 9
 - chitterlings, 8
 - feijoadas, 9
 - goat, 10
 - heart and liver, 7
 - lard and tallow, 9
 - lungen stew, 9
 - pig, 10
 - porcine offal and cartilaginous tissue, 10
 - pork tongue slices, 10
 - sausages, 9
 - sheep intestines, 10
 - sweetbreads, 7
 - tongue and kidney, 7
 - tripe, 7–8
 - vastedda, 9
 - food safety issues, 10–11
 - mammalian offal, 4
 - meat consumption, 3
 - mineral element contents, 185
 - nutrient content, 4–6
 - zinc contents, 185
- o*-phthalaldehyde (OPA), 129–130
- Organochlorine (OC), 380–381
- Organophosphates, 380–381
- Oxidation
 - edible animal by-products
 - oxidation, 65–66
 - ROS, 65
 - lipid oxidation
 - mechanisms and factors, 67
 - primary oxidation changes, 67–70
 - secondary oxidation changes, 71–73
 - protein oxidation
 - DNPH method, 75–76
 - mechanisms and factors, 74
 - protein cross-links, 78
 - protein semialdehydes, 76–77
 - tryptophan depletion, 75

P

- Pancreas
 - cholesterol, 56–57
 - conjugated linoleic acid
 - beef, 149
 - pork, 150
 - definition, 7
 - fatty acid content and composition
 - beef, 145–146
 - pork, 147–148
 - riboflavin, 169
- Pantothenic acid, 174
- PCA, *see* Principal component analysis
- PCBs, *see* Polychlorinated biphenyls
- PCR, *see* Polymerase chain reaction
- PCR-RFLP, 289
- Pesticides
 - analytical determination, 377
 - analytical method, 387
 - carbamates, 380
 - chromatography techniques, 392
 - column chromatography, 389
 - 2D chromatogram, 395
 - edible animal by-products, 382–383
 - extraction and purification techniques, 391
 - fluorescence polarization immunoassay, 392
 - gas chromatography methods, 384–385
 - GC-ECD, 393
 - GC-MS/MS, 393, 934
 - GC systems, 392
 - GPC techniques, 390

- HPLC methods, 386
 - HS-SPME procedures, 389
 - immunoassays, 391
 - legislation, 378–380
 - levels of pesticides, 395–396
 - liquid chromatography, 390–391
 - MAE techniques, 388
 - matrices variability, 377
 - MSPD extraction procedure, 388
 - organochlorine, 377, 380
 - organophosphates, 380
 - PLE techniques, 388–389
 - solvent extraction techniques, 387
 - SPE process, 389
 - structure of, 381–382
 - triazines, 380, 393
 - uses, 380
 - Phenylisothiocyanate (PITC), 128
 - Phenylthiocarbamyl (PTC), 128
 - PLE, *see* Pressurized liquid extraction
 - Polychlorinated biphenyls (PCBs), 441
 - Polychlorinated biphenyls, environmental contaminants
 - edible meat by-products, 442
 - equipment, 442–443
 - PCBs and organochlorinated
 - edible meat by-products, 445
 - lipophilic properties, 446
 - PCBs, 445–446
 - target compounds, 444–445
 - toxicological effects, 441
 - Polymerase chain reaction (PCR), 224, 307–308
 - Polymerase chain reaction denaturing gradient gel electrophoresis (PCR-DGGE), 230
 - Polyunsaturated fatty acids (PUFA), 71, 112
 - Pressurized liquid extraction (PLE), 388
 - Principal component analysis (PCA), 26
 - Protein oxidation
 - DNPH method, 75–76
 - mechanisms and factors, 74
 - protein cross-links, 78
 - protein semialdehydes, 76–77
 - tryptophan depletion, 75
 - PTC, *see* Phenylthiocarbamyl
- R**
- Radiochemical neutron activation analysis (RNAA), 190
 - Reactive-oxygen species (ROS), 65
 - Recommended daily allowances (RDA)
 - carbohydrate content, 120
 - divalent magnesium, 111
 - sodium, 111
 - vitamins, 120
 - Rendered fats
 - chemistry of, 38
 - dry rendering method, 37
 - heating process, 38
 - lipid species, analysis of
 - fatty acid composition, 39
 - iodine number, 39
 - melting point, 39–40
 - oxidative rancidity, 40
 - tanking, 37
 - uses, 38

- Retinol equivalents (RE), 166
 - Riboflavin (vitamin B₂), 169–170
 - ROS, *see* Reactive-oxygen species
 - Ruminant stomachs, 212
- S**
- Saccharomyces uvarum*, 171
 - Saturated fatty acids (SFA), 112
 - SEC, *see* Size-exclusion chromatography
 - Selenium, 191
 - Semisynthetic antibiotics, 355
 - Sensorial quality, 88
 - SEP, *see* Standard error of prediction
 - SFA, *see* Saturated fatty acids
 - Silver ion chromatography
 - hyphenated techniques, 143
 - spectroscopy, 142–143
 - ultra-performance liquid chromatography, 143
 - Silver ion high-performance liquid chromatography, 144–145
 - Size-exclusion chromatography (SEC), 198
 - Sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE), 23, 78
 - Solid-phase extraction (SPE), 29, 338, 389
 - Solid-phase microextraction (SPME), 73
 - Specified risk material (SRM)
 - bovine animals, 301
 - CNT-based, 302, 304
 - meat and processed meat, 303
 - non-neuronal, 302
 - ovines and caprines, 302
 - SPME, *see* Solid-phase microextraction
 - Spoilage detection
 - analysis methods
 - chemometrics, 214–215
 - microbial populations, 215
 - pH, 214
 - predictive microbiology, 215
 - animal intestines, 212
 - blood, 210–211
 - brain, 211
 - edible udder, 212
 - extrinsic factors, 208–209
 - glucose, 213
 - heart, 211
 - intrinsic factors, 208
 - kidneys, 211
 - lactic acid bacteria, 213
 - liver, 211
 - liver microbial spoilage, 213
 - nonpregnant pig uteruses, 212
 - polyunsaturated fatty acids, 210
 - protein content, 209–210
 - pseudomonads, 213
 - ruminant stomachs, 212
 - spleens, 212
 - sweetbreads, 212
 - vitamins, 210
 - SRM, *see* Standard reference material
 - Standard error of prediction (SEP), 22
 - Standard reference material (SRM), 191
 - Sulphonamides, 357
 - Sweetbreads, 212

T

- TCA, *see* Trichloroacetic acid
- TEF, *see* Toxic equivalent factor
- Tetracyclines, 357
- Tetrahydrofolic acid (THF), 172
- Thermospray flame furnace atomic absorption spectrometer (TS-FF-AAS), 194
- Thiamin (vitamin B₁), 168–169
- TMS, *see* Trimethylsilyl
- Tongue
 - blanch, 7
 - cholesterol, 57–58
 - conjugated linoleic acid
 - beef, 149
 - pork, 150
 - fatty acid content and composition
 - beef, 145–146
 - pork, 147–148
- Toxic equivalent factor (TEF), 441
- Toxins
 - bacterial toxins, 243–244
 - mycotoxins
 - cleanup procedures, 240–241
 - laboratory precautions, 240
 - OTA, 230, 239
 - pre-concentration, 240–241
 - quantitative methods and detection systems, 241–243
 - sample preparation, 240–241
 - screening tests, 241
- Transmissible spongiform encephalopathy (TSE); *see also* Neuronal and non-muscle tissues detection
 - bovine, 301–302
 - exposition risk, 301
 - infectivity, 301–302
 - PrP^{Sc} detection, 305
 - sporadic, 302, 310
 - transmissibility, 304
- Triazines
 - chromatograms, 393
 - structure of, 380–381

- Trichloroacetic acid (TCA), 30, 127
- Trimethylsilyl (TMS), 46

U

- Ultra high temperature (UHT), 30
- Ultra-performance liquid chromatography (UPLC), 143

V

- variant Creutzfeldt-Jakob disease (vCJD), 25
- Vitamin A, 163, 165
- Vitamin B₆, 171–172
- Vitamin B₁₂, 173–174
- Vitamin C, 175–176
- Vitamin D, 166–167
- Vitamin E, 167
- Vitamin K, 167–168

W

- Water-holding capacity (WHC), 92
- Water-soluble vitamins
 - biotin, 174–175
 - folate, 172–173
 - niacin, 170–171
 - pantothenic acid, 174
 - riboflavin, 169–170
 - thiamin, 168–169
 - vitamin B₆, 171–172
 - vitamin B₁₂, 173–174
 - vitamin C, 175–176
- Western blot, 304–306
- Wet digestion, 417
- Wijs method, 39

X

- X-ray fluorescence (XRF)
 - application techniques, 193
 - channel electron multiplied arrays, 192
 - determinations, 192–193
 - limitations, 192