

Volume 1

Handbook of Poultry Science and Technology

Primary Processing

Editor

Isabel Guerrero-Legarreta, Ph.D.

Consulting Editor

Y.H. Hui, Ph.D.

Associate Editors

Alma Delia Alarcón-Rojo, Ph.D., Christine Alvarado, Ph.D., Amarinder S. Bawa, Ph.D., Francisco Guerrero-Avendaño, Ph.D., DVM., Janne Lundén, DVM, Ph.D., Lisa McKee, Ph.D., Yoshinori Mine, Ph.D., Casey M. Owens, Ph.D., José Angel Pérez-Álvarez, Ph.D., Joe M. Regenstein, Ph.D., Marcelo R. Rosmini, Ph.D., Jorge Soriano-Santos, Ph.D., J. Eddie Wu, Ph.D.

 **WILEY**



Copyright © 2010 by John Wiley & Sons, Inc. All rights reserved.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.

Published simultaneously in Canada.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4470, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at <http://www.wiley.com/go/permission>.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information on our other products and services or for technical support, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic formats. For more information about Wiley products, visit our web site at www.wiley.com.

Library of Congress Cataloging-in-Publication Data:

Handbook of poultry science and technology / editor, Isabel Guerrero-Legarreta; consulting editor, Y.H. Hui; associate editors, Alma Delia Alarcón-Rojo ... [et al.]

p. cm.

Includes index.

ISBN 978-0-470-18537-7 (2-vol. set)

ISBN 978-0-470-18552-0 (v. 1)

ISBN 978-0-470-18553-7 (v. 2)

1. Poultry—Processing. 2. Poultry plants. I. Guerrero-Legarreta, Isabel.

TS1968.H36 2009

664'.93—dc22

2009014025

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

CONTENTS

Contributors

Preface

PART I POULTRY: BIOLOGY TO PREMORTEM STATUS	1
1 Poultry Biology, Classification, and Trade Descriptions	3
<i>Y.H. Hui and Isabel Guerrero-Legarreta</i>	
2 Competitive Exclusion Treatment in Poultry Management	19
<i>Carita Schneitz and Geoffrey Mead</i>	
3 Premortem Handling	45
<i>Lorenzo Antonio Durán-Meléndez</i>	
4 Transportation to the Slaughterhouse	55
<i>Daniel Mota Rojas, Miguel González Lozano, and Isabel Guerrero-Legarreta</i>	
PART II SLAUGHTERING AND CUTTING	69
5 Slaughterhouse Building and Facility Requirements	71
<i>Daniel Mota Rojas, Miguel González Lozano, and Isabel Guerrero-Legarreta</i>	
6 Slaughtering Equipment and Operations	79
<i>Juana Fernández-López, Esther Sendra-Nadal, and Estrella Sayas-Barberá</i>	

ix

xiii

1

3

19

45

55

69

71

79

v

- 7 Poultry Carcass Evaluation and Cutting**
Lorenzo Antonio Durán-Meléndez

- 8 Official Control of Slaughterhouses and Processing Plants**
Nina Kaario and Janne Lundén

- 9 Poultry Packaging**
Alfonso Totosaus-Sánchez

- 10 Kosher Laws in Food Processing**
Joe M. Regenstein and Carrie E. Regenstein

- 11 Food Production from the Halal Perspective**
Yaakob B. Che Man and Awis Qurni Sazili

PART III PRESERVATION: REFRIGERATION AND FREEZING

- 12 Biochemical Changes During Onset and Resolution of Rigor Mortis Under Ambient Temperature**
Estrella Sayas-Barberá, Juana Fernández-López, and Esther Sendra-Nadal

- 13 Physicochemical Changes During Freezing and Thawing of Poultry Meat**
Alma Delia Alarcón-Rojo and Héctor Janacua-Vidales

- 14 Low-Temperature Storage of Poultry**
María Elena Carranco-Jáuregui, Silvia Carrillo-Domínguez, and María de la Concepción Calvo Carrillo

- 15 Engineering Principles of Freezing**
Liliana Alamilla-Beltrán, José Jorge Chanona-Pérez, José Fernando González-Sánchez, and Gustavo F. Gutiérrez-López

- 16 Quality of Frozen Poultry**
Esther Sendra-Nadal, Estrella Sayas-Barberá, and Juana Fernández-López

- 17 Quality of Refrigerated Poultry**
Vandana Sohlia and Amarinder S. Bawa

- 18 Refrigeration Equipment and Operations**
Mallika Manral and Amarinder S. Bawa

101

107

121

131

183

217

219

243

263

283

293

307

325

- 19 Freezing Equipment and Operations**
Martha Yarely Leal Ramos

- 20 Refrigeration and Freezing in Central Facilities and Retail Stores**
K. Radakrishna, Vandana Sohlia, and Amarinder S. Bawa

- 21 Refrigeration and Freezing in Industrial Food Facilities (Hospitals, Restaurants, Factories)**
Vandana Sohlia and Amarinder S. Bawa

PART IV PRESERVATION: HEATING, DRYING, CHEMICALS, AND IRRADIATION

- 22 Heating, Drying, and Chemicals**
José Arturo García-Macías

- 23 Irradiation**
María Pilar González-Santiago, Beatriz Caballero-Santos, Magdalena Tudela-Carrasco, and José María Fernández-Ginés

PART V COMPOSITION, CHEMISTRY, AND SENSORY ATTRIBUTES

- 24 Quality Characteristics of Poultry Products**
Sarah Padilla

- 25 Chemical Composition and Nutritional Content of Raw Poultry Meat**
Jorge Soriano-Santos

- 26 Poultry Meat Tender ness**
Casey M. Owens and Jean-François C. Meullenet

- 27 Pale, Soft, and Exudative Poultry Meat**
Casey M. Owens and Jason K. Apple

PART VI EGGS

- 28 Nutritional and Health Attributes of Eggs**
Yuan Ren, Jianping Wu, and Robert Renema

349

377

397

419

421

431

451

453

467

491

515

533

535

CONTENTS

viii

29 Functional Properties of Egg Components in Food Systems	579
<i>Yoshinori Mine and Marie Yang</i>	
 PART VII SANITATION AND SAFETY	 631
30 Chemical Residues: Pesticides and Drugs (β-Agonists and Antibiotics)	633
<i>María de Lourdes Pérez-Chabela</i>	
31 Factors Affecting Microbial Growth in Fresh Poultry	643
<i>Carol W. Turner</i>	
32 Basic Principles of the HACCP System in the Poultry Industry	655
<i>Chitra Wendakoon</i>	
33 HACCP in Poultry Slaughterhouses	667
<i>Marjatta Rahkio</i>	
34 Online Inspection	683
<i>Kevin Chao</i>	
35 Poultry-Related Foodborne Disease	703
<i>Lisa McKee</i>	
36 Poultry-Related Foodborne Diseases in Central and South America	717
<i>Gabriel J. Sequeira, Luis E. Martí, and Marcelo R. Rosmini</i>	
37 Overview of Poultry Processing and Workers' Safety	737
<i>Y.H. Hui and Isabel Guerrero-Legarreta</i>	
38 Poultry-Processing Industry and eTool	753
<i>Y.H. Hui and Isabel Guerrero-Legarreta</i>	
Index	773
Contents of Volume 2: Secondary Processing	785

CONTRIBUTORS*Editor*

Isabel Guerrero-Legarreta, Departamento de Biotecnología, Universidad Autónoma Metropolitana, México D. F., México

Consulting Editor

Y.H. Hui, Science Technology System, West Sacramento, California

Associate Editors

Alma Delia Alarcón-Rojo, Facultad de Zootecnia, Universidad Autónoma de Chihuahua, Chihuahua, México

Christine Alvarado, Department of Animal and Food Sciences, Texas Tech University, Lubbock, Texas

Amarinder S. Bawa, Defence Food Research Laboratory, Siddartha Nagar, Mysore, India

Francisco Guerrero-Avendaño, Archer Daniels Midland Co., Mexico

Janne Lundén, Department of Food and Environmental Hygiene, Faculty of Veterinary Medicine, University of Helsinki, Helsinki, Finland

Lisa McKee, Department of Family and Consumer Sciences, New Mexico State University, Las Cruces, New Mexico

Yoshinori Mine, Department of Food Science, University of Guelph, Guelph, Ontario, Canada

Casey M. Owens, Department of Poultry Science, University of Arkansas, Fayetteville, Arkansas

José Angel Pérez Alvarez, Grupo Industrialización de Productos de Origen Animal (IPOA Research Group), Departamento de Tecnología Agroalimentaria,

Support Task: Knife Person A knife person collects dull knives from employees along the processing lines and replaces them with sharp ones. This employee may also sharpen knives that have been collected. Hazards of this task may include slips, trips, and falls; and hazards from the use of grinders.

Slips, Trips, and Falls

HAZARDOUS SITUATION Workers walk all over the facility on wet floors that may have bird skin, bird parts, and ice on them, creating a slipping hazard. Metal drain covers on the floor are also very slippery and pose a hazard. A falling worker may contact dangerous equipment or may cut him- or herself on a knife blade.

POSSIBLE SOLUTIONS

- Cover drains with nonslip grating.
- Provide workers with nonslip footwear and require its use.
- Paint floors with slip-resistant paint or install nonslip floor tile.
- Provide guardrails at workstations adjacent to dangerous equipment, to prevent injury.
- Carry knives in sheaths or closed containers.

Hazards from the Use of Grinders

HAZARDOUS SITUATION Employees may suffer cuts, lacerations, skin abrasion, contusions, or eye damage during use of grinders to sharpen knives. Grinding wheels may break up or explode. Bits and pieces of knife blades may be thrown off during sharpening.

POSSIBLE SOLUTIONS

- Use safety goggles or other protective eyewear.
- Use only grinding wheels with an rpm rating that matches the spindle speed of the grinder.
- Use a ring test procedure to check for nonvisible damage to the grinding wheel.
- Follow the manufacturer's recommendations for guarding and use of the grinding wheel.

Personnel managing the safety of workers in a poultry-processing plant should access the OSHA Web site to obtain complete details about the eTool for poultry processing. The information presented in this chapter illustrates the importance and applications of those guidelines.

INDEX

- Acinetobacter*, 315
- Additives, 299
- Adweek Magazine, 134
- Aeromonas*, 315, 723
- Age, 494
- Al Kitabe, 139, 155
- American Humane Association, 166
- American Meat Institute (AMI), 139, 164, 169, 171
- American Society for the Prevention of Cruelty to Animals, 170, 172, 176
- Animals, 186, 190–192, 194–198, 200, 205–209, 214
- camel, 196
- cats, 190
- cattle, 190, 193
- crustaceans, 190
- dogs, 190, 206, 207
- goat, 204
- halal species, 191, 195
- khinzir*, 206, 207
- pigs, 190, 200, 206, 207
- poultry, 183, 184, 191, 194, 195, 197–202, 208, 209, 212, 215
- predatory birds, 190
- prey, 190, 207
- sheep, 204
- swine, 187, 188, 196
- tigers, 190, 207
- well-being, 56
- Animal transportation, 56
- bruising, 61, 64
- cages and crates, 57
- corticosteroid level, 57, 62
- dead on arrival, 56
- glucose level, 57
- holding time in stockyards, 60
- humane treatment, 56
- hygiene, 61
- lactate level, 57
- loading, 57
- mortality, 56, 57, 59, 63
- space allowance, 57
- stress factors, 58, 64
- trauma, 56
- weather effect, 58
- Antibiotics, 637–638, 724
- allergic reactions, 637
- alternatives, 638
- animal waste, 637
- antibiotics permitted, 638
- antibody therapy, 638
- excretion in feces and urine, 637
- serum therapy, 638
- Allo-Kramer (AK), 498–500, 507–509
- Aroma, 457–459
- Ashkenazic Jews, 149, 154
- Bacillus cereus*, 723, 728
- Bacon, 191
- Baligh*, 195
- B'de-eved, 151
- Beeswax, 138
- Begissing, 141
- Beit Yosef, 140, 149

Handbook of Poultry Science and Technology, Volume 1: Primary Processing, Edited by Isabel Guerrero-Legarreta and Y.H. Hui
Copyright © 2010 John Wiley & Sons, Inc.

Beverages, 190, 194, 207
 alcoholic drinks, 184, 186, 207
 beer, 194
 malt, 194
 wine, 194
 Biological and legal classification of poultry in the United States, 9
 poultry parts, 13
 ready-to-cook poultry, 9
 Biological hazards, 658–659
 Biotechnology, 190, 191, 215
 Birds, common to the live-bird marketing system, 9
 Bishul Yisroel, 151
 Bleeding, 198, 201, 207, 208, 214
 Blood, 186–188, 195, 196, 206, 207
 Bodek, 140
Brochothrix thermosphacta, 315
 Bruise, 198, 199
 Burger King, 168
 By-products, 190, 195, 198, 202, 207
 CAC (Codex Alimentarius Commission), 204, 426
 standards, 668, 681
 Camel's milk, 146
 Carmine, 136
Campylobacter, 30, 315, 644, 646, 647, 648, 650, 651, 705, 706, 718, 723
Campylobacter jejuni, 706, 708–709, 711
 Canola seeds, 553
 Carbohydrate, 469
 Carcass, 101–104, 198, 202, 203
 Cardiac arrest, 196
 Carotid arteries, 196, 197, 200, 201, 202, 207, 208
 Carrion, 186, 187, 195, 206, 207
 Certification, 200, 213
 Chabad, 144
 Chai, 148
 Chalef, 138, 139, 166, 171
 Challah, 152
 Chemical hazards, 659
 Chest, 196
 Chicago Rabbinical Council, 159
 Chicken
 featherless, 137
 nuggets, 712
 Chicken, commercial production, *see* Commercial production of chicken
 Chodesh, 147
 Cholesterol, 562
 Cholev Yisroel, 146, 147
 Chometz, 136, 148, 149, 152, 158

CIS (Commonwealth Independent States), 185
 Cleaning a unit for a new flock, 6
 Cleanliness, 189, 205
Clostridium, 30, 315, 710, 728
 Cochineal, 136
 Codex, 184, 204, 214
 Color, 191, 192, 254, 266–268, 294, 311, 455–457, 516–517, 526, 636
 age and, 457
 bone darkening, 255, 256
 carotenoids, 266, 267
 changes, 254
 cured meat color, 424
 discoloration, 255, 256
 effect of refrigeration, 267
 feed and, 455
 frozen poultry, 294
 hemoglobin, 267
 irradiation and, 456
 lightness, 516, 526
 mechanically deboned meat, 255
 myoglobin, 267
 oxidation, 266, 276
 pH, 455
 pigments, 267, 268
 PSE meat, 256
 processing and, 455–457
 skin color, 266, 267
 storage effect, 256
 xanthophylls, 266
 Colorado State University, 167
 Commercial CE products, 22
 avifree, 22
 aviguard, 22
 broilact, 22
 MSC, 22
 preempt, 22
 Commercial production of chicken, 4
 Competitive exclusion or the Nurmi concept, 20
 application, 28
 bird performance, 30
 CE, 20
 chick assay, 23
 mechanism, 27
 pure-culture preparations, 26
 undefined cultures, 22
 Compliance, 109, 110, 111, 112, 185, 211, 212
 Confusion, 194
 Congruence, 117, 118
 equal requirements, 118
 Conjugated linoleic acid (CLA), 540, 560
 Connective tissue, 495, 504
 Consumers, 185, 191, 194, 195, 204, 205
 Consumption, 453–454

Contamination, 193, 194, 198, 209, 210
 cross-contamination, 193, 194, 707–710
 Control authorities, 108, 118
 central, 109
 local, 108
 regional, 108
 Control methods, 111
 audit, 109, 111
 inspection, 111
 monitoring, 111
 sampling, 111, 112
 surveillance, 111
 verification, 111
 Control procedures, 108, 109, 110, 112, 116
 Coors Brewing, 135
 COR, 163
 Cornell Kosher (and Halal) Food Initiative, 167
 Cornell University, 135, 159, 167
 Countries, 184, 185, 194, 204, 205, 208, 213, 214
 developed, 185
 developing, 184, 185, 204, 214
 Muslim, 184–190, 194–196, 198, 200–203, 208, 211, 213–215
 non-Muslim, 185
 CRC Press, 159
 Cross contamination, 426
 Curing ingredients, 428
 ascorbate, 429
 liquid smoke, 429
 nitrites, 428
 phosphates, 428
 salt, 428
 sugar, 429
 Cutting and deboning, 757
 Dannon Yogurt, 135
 Dark firm dry meat (DFD), 235
 Death, 188, 196, 198, 199, 201, 203, 207, 208
 Deboning, 203
 Deemed, 191, 208, 211, 213
 Demand, 184, 185
 Dhabiba halal, 161
 Dietary, 468
 daily value, 468
 MyPyramid, 471
 nutrition facts, 468
 reference intakes, 468
 vegetarian diets, 471
 Dietary laws
 Jewish, 132
 Diseases: precautions, pest control, and records, 7
 feed, 8
 grow-out phase, 5
 growth and nutrition, 8
 harvesting meat chickens, 6
 housing structure, 4
 receipt of chicks, 4
 Distress, 198
 Distribution, 184, 186, 191, 194–202, 204, 205, 208, 214
 Disulfide exchange, 598
 Documentation, 109, 115, 116
 corrective action, 115
 objective evidence, 115
 photographs, 115
 Doubtful, 184, 187, 189
 Dressing, 191, 203
 Drinks, 184, 186, 190, 191, 205, 207, 214
 Drip loss, 257
 cell disruption, 257
 frozen storage, 257, 314
 Drugs, 636–638
 anabolic steroids, 636
 β-adrenergic, 636
 β-agonist, 637
 clenbuterol, 636
 toxicity, 637
 Drying, 425–427, 601
 dry-heating, 601, 613
 meat dehydration, 425
 relative humidity, 427
 D'var Hadash, 143
 Eggs
 formation, 538
 functional properties, 580, 595–602
 hen eggs, 580
 nutritional value, 544–565
 production, 537
 quality, 541
 structure, 581–604
 eggshell, 581
 egg yolk, 583–610
 egg yolk carbohydrates, 589
 egg yolk lipids, 588–609
 egg yolk proteins, 583–588
 egg white, 591
 egg white proteins, 591–604
 Electrical stimulation, 721
 Emulsifiers, 191
 Endorphins, 169
Enterobacteriaceae, 315
 Enzymes, 190, 191
 Equipment kosherization, 144, 145, 150, 151, 153
Escherichia coli, 30, 315, 649, 705, 728
 Esophagus, 196, 197, 200–202, 207, 208

eTool, contents, 755
eTool, examples, 757
 cutting and deboning, 757
 NIOSH lifting recommendations, 760
 positioning, 760
 rotation strategies, 761
 tasks, 763
eTool, in poultry-processing, 755
Evisceration, 198

FAO (Food and Agriculture Organization), 204
Farm, 191, 202, 213
Farm Animal Welfare Committee (UK), 167, 178, 179
Fatwa, 191, 200
Flaxseed, 551
Flavor, 253, 274, 312, 457–459
 compounds contributing to, 457–458
 effect of diet, 458
 effect of refrigeration, 276
 irradiation, 459
 odor substances, 274
 raw meat, 457
 shelf life, 254
 taste panel, 254
 umami, 274
Flesh, 188, 194, 196
Feed, 198
 feed withdrawal, 198
Food, 184–198, 200, 202–215
 business operator, 108
 legislation, 108
 processing, 192, 193, 212
 production, 184–186, 188, 190–194, 196, 198, 200, 202, 204–206, 208, 210, 212, 214, 215
 safety, 118
Food-chain information, 672, 680
Foodborne diseases, 703–705
 outbreak estimates, 704
 poultry-related estimates, 705
 surveillance and reporting systems, 704
Food Marketing Institute (FMI), 139, 164, 167, 168, 169, 170
Food-processing operations, 193
 centrifugation, 193
 cleaning, 193–195
 cleansing, 192, 193
 conversion, 192, 193, 209
 crystallization, 193
 cumbersome cleansing, 193
 drying, 193
 emulsification, 193
 expression, 193, 205, 211, 212

INDEX

filtration, 193
freezing, 193
high-pressure, 616
irradiation, 193
membrane separation, 193
mixing, 193
pasteurization, 193
preservation, 192, 193
poultry processing, 183, 191–193, 198, 205, 206, 209–212, 215, 671
pulsed electric field, 616
screening, 193, 210
size reduction, 193
solid-liquid extraction, 193
sterilization, 193
Forbidden, 188, 189, 190, 196, 207

Gebruckts, 149
Gel, 518
Gelatin, 191
Gemmorrah, 133
Genes, 191
Genetic engineering, 191
Gevinas Yisroel, 145
GHPs (good hygiene practices), 206, 210, 668
Glatt kosher, 140, 142, 156, 161, 169, 175
Globalization, 185
Glottis, 196, 208
GMOs (genetically modified organisms), 190, 207
GMPs (good manufacturing practices), 193, 205, 210, 668, 722
Good Housekeeping Seal of Approval, 134
Gray area, 186, 187, 189
Growth rate, 520–522
Guidelines, 184, 189, 191, 203–206, 210, 212, 214
Gut content, 198

Halal, 184–215
 checker, 200, 202, 203
 food supply chain, 191, 192
 meat, 202
 slaughtering, 183, 194–202
 species, 191, 195
 Halalan Thoyyiban, 188
Halqum, 196, 201, 207, 208
Ha'Shulcan, 133
Hadar, 160
Hadith, 187, 189
Hagalalah, 151
Halacha, 133, 140, 141
Half Moon K, 159
Halqum, 196, 201, 207, 208

INDEX

Halothane, 519
Hanafi, 190, 206
Handling, 191, 192, 197–199, 202, 205, 209, 212, 214
Hand washing, 707–710
Haram, 184–189, 190–194, 198, 202, 205, 212, 214
Harmful, 187, 189, 206, 209, 210
Hayat al-mustaqirrah, 195, 200, 208
Hazard analysis critical control points (HACCP), 205, 206, 210, 644, 651, 656–664, 721
 corrective actions, 660
 critical control points, 659, 668, 679
 critical limits, 659
 documentation, 661
 hazard analysis, 657–659, 668, 674, 675
 implementation, 663–664
 monitoring, 660
 plan development, 661–663
 prerequisite programs, 663
 verification, 660–661
 principles, 657
Hazardous, 190, 191, 195, 207, 210
Heating, 421, 521–523
 heat transfer in meat and meat products, 421–423
 commercial sterility, 422
 D-values, 422
 principles, 423
 thermal destruction time, 422
 meat changes during heat processing, 423–424
Hebrew National, 134
Holy Scriptures, 133
Hormones, 190
Host specificity, 29
 chicken, 29
 turkey, 30
Humane, 195, 197
Humane Farm Animal Care, 166
Hydrogen bonding, 597
Hydrophobic interactions, 597
Hygram, 673
Hyperspectral line-scan imaging, 688
 background removal, 689
 region of interest (ROI) optimization, 689, 693, 694
 waveband and ratio selection, 689, 690, 693, 694

Incongruence, 118
Industry, 184, 185, 191, 198, 205, 212–215
Ingredients, 190–193, 206, 208–210, 211, 212, 215
Ijma', 184

Immolating, 187
Impurities, 186, 195
Insect contamination, 426
Intention, 187, 195, 208
International trade, poultry, 15
Intoxicants, 186, 187
IPM, 138
Irradiation, 193, 432, 608, 616
 conditions for authorizing, 445
 detection, 440
 egg gamma irradiation, 608, 616
 legislation, 444
 microorganism, 434
 nutritional effects, 438
 physicochemical effects, 436
 sensory effects, 437
 radappertization, 434
 radurization, 434
Irui, 151
Islam, 186–190, 195, 197, 200, 205–208, 211, 214
 scholars, 184, 193, 195
Islamic Food and Nutrition Council of America, 161, 165

JAKIM (Department of Islamic Development Malaysia), 190, 191, 202, 205

Jewish dietary laws, 132

Jugular veins, 196, 197, 200–202, 207, 208

Juiciness, 495

Kashrus, 132
Kashrus.com, 162
Kashrus Council of Toronto, 163
Kashrus magazine, 159, 160, 162
Kavoush, 142
Kedem, 149
Kellogg, 159
Kentucky Fried Chicken, 168
Khamr, 186, 207
Kitnyos, 154, 158
Knife, 195, 196, 198, 200–202, 208, 209
 sharp, 191, 193
Kof-K, 159, 163
Kosher, 131–181, 184, 185, 213, 215
 equipment kosherization, 144, 145, 150, 151, 153
 glatt, 140, 142, 156, 161, 169, 175
 health aspects, 134
 koshering meat, 142
 market, 134
 salt, 142

- Kosher Enforcement Bureau, New York, 163
Kosher overseers, 159
- Labeling, 193, 202, 204, 205, 210, 212, 213
Lac resin, 137, 138, 143
Lairage, 198
Lard, 191, 212
L'Chaim, 148
L'Chatchilla, 151
Legislation, 72, 74, 184, 203, 205, 207, 209–211
Levy's Rye Bread, 134
Liebers, 160
Line-scan imaging system, 686
 EMCCD camera, 686
 image binning, 687
 relative reflectance, 688
 spectrograph, 686, 687
 waveband calibration, 688
Lipids, 191, 469, 476
 antioxidants, 248, 276, 554
 BHA, 251
 BHT, 250, 251
 cholesterol, 249, 477, 478, 479
 effect of diet, 249, 250
 fat source, 249
 fatty acids, 476
 frozen poultry, 296
 irradiation, 251
 off-flavors, 247
 omega-3, 537, 550, 564
 omega-3 enriched eggs, 550
 oxidation, 246, 250, 274, 296
 packaging, 251
 polyunsaturated lipids, 248, 249, 254, 476,
 477, 478, 479
 rancidity, 247
 saturated, 476
 skin, 476
 storage temperature, 246, 247
 TBA values, 248, 249
 unsaturated lipids, 248, 249, 469, 476
 vitamin E, 248, 249
Listeria, 30, 315, 646, 650, 705, 723
Lubavitch, 144
Lutein, 557
- M and Ms, 154
Machine vision spectroscopy/imaging research
 for food and agriculture, 685, 686
 fluorescence, 685
 reflectance, 685, 686
 RGB color, 685
 visible/near-infrared, 685, 686
Maillard browning, 274, 458–459, 615

- Manischewitz, 149
Marc alcohol, 145
Mare's milk, 146
Mari', 196, 201
Marine algae, 553
Maris Ayin, 143
Mashgiach, 138, 150, 152
Malignant hyperthermia, 519
Marination (marinade), 524–525
Matzos, 148
 ball soup, 149
 flour, 149
 meal, 149
 schmura, 148
Mazhab, 206
McDonalds, 168
Meals ready-to-eat (MRE), 161
Meat, 185, 186, 188, 193–197, 202, 204,
 211–214, 467, 468, 471, 308–311
 attributes, 264
 chicken, 467, 471, 472, 476, 479, 480, 482,
 483, 484
 composition, 719
 duck, 467, 472, 476, 482, 484, 485
 meat by-products, 195, 202
 meat quality, 62–63, 308
 effect of food deprivation, 63
 effect of glycogen concentration, 63
 effect of transportation, 62
 mechanical slaughter, 200, 201, 203
 blades, 184, 198
 knife, 200, 201, 209
 nutritional value, 719
 pheasant, 475
 quail, 472
 turkey, 137, 467, 471, 472, 476, 479, 481,
 482, 484, 485
Mehadrin, 141
Melicha, 141
Menacker, 141
Menhaden oil, 553
Merciful, 188, 195, 197, 208
Mevushal, 145
Microbial growth in fresh poultry, 645–648
 biological structures and, 646–647
 environmental gases and, 647–648
 moisture content and, 645–646
 nutrient content and, 646
pH, 645
 relative humidity, 647
 storage temperature and, 647
 water activity (a_w) and, 646
Microbiology, 121, 190, 207, 210, 648, 302, 315,
 425

- Mikvah, 152
Minerals, 471, 479
 calcium, 471, 479
 iron, 471, 479
 phosphorous, 472, 479
 selenium, 481, 556
 zinc, 471, 481
Minhag, 144
Mishnah, 133
Molten globule, 596, 597
Moraxella, 315
Moses, 133
Mughallazah, 200, 206, 209
MUI (Majlis Ulama Indonesia), 213
MUIS (Singapore Islamic Council), 202, 213
Mukhaffafah, 206
Multispectral line-scan inspection, 690, 696
 bird detection algorithm, 690, 691, 692
 fuzzy logic membership functions, 692, 697
 ROI analysis and classification algorithm, 692,
 696, 697, 698
Mumayyiz, 195
Muscle, 228, 263–264
 conversion of muscles to meat, 228
 extracellular changes, 266
 muscle changes
 postmortem factors, 230, 235
 premortem factors, 234
 physiology and biochemistry, 226
prerigor stage, 229
sarcomere, 493, 503–504, 508
 structure, 221
Mushbooh, 184–187, 191, 212
Mushroom, 190, 207
Muslim, 184–190, 194–196, 198, 200–203, 208,
 211, 213–215
Mutawassitah, 207
Mycotoxins, 724
- Nabisco, 135
Nahr, 196
Najs, 184, 192, 193, 200, 206, 207, 209, 210
National Council of Chain Restaurants (NCCR),
 139, 164, 167, 168, 169, 170
Neck, 196–198, 200, 208
New Jersey State Supreme Court, 163
New York Department of Agriculture and
 Markets Kosher Enforcement Bureau, 163
Nikkur, 141, 149
NIOSH lifting recommendations, 760
Niyyah, 195, 208
Noncompliances, 109, 110, 113, 115, 116
North American Industrial Classification System,
 739
- Not permissible, 184, 194
Nutritional value, 257
- Offal, 203, 213
Official control
 action plan, 116
 approval, 110
 audit, 109, 111
 control plan, 110
 corrective action, 115, 116
 economic implication, 111
 enforcement measures, 116
 export, 110
 final meeting, 115
 follow-up, 116
 impartiality, 109
 import, 119
 independence, 112
 in-house control, 111, 113, 114
 in operation, 113
 on-site control, 110, 113, 117
 quality control system, 108
 risk-based, 110
 targets, 114
 transparency, 109, 112
Official food control, effectiveness, 116
 audit, 117
 indicator, 117
 on-site inspection, 117
 removal of non-compliances, 116
 resources, 116
OIE (Office of International Epizootics), 204
Oils, 191
OK, 159
Organic livestock, 639
Organized Kashrus Laboratories, 159
Orleh, 147
OU, 159
Outbreaks, 718, 726–727
 associated to industrialization, 721
 associated to production, 720
 causal agents, 718
Outsourcing, 118
 competence, 118
 effectiveness, 118
 flexible application of legislation, 118
 food safety, 118
Overrun, 604
Oviduct, 536
- Packaging, 191–194, 202, 203, 206, 209, 210,
 301, 333
 casings, 193
 cellulose, 193

Packaging (*contd.*)
 chemical treatment, 122–124
 acid and alkaline solutions, 124
 chlorine, 122
 EDTA, 123
 hypochlorous acid, 123
 nisine, 123
 paracetic acid, 124
 potassium sorbate, 123
 quaternary ammonium, 124
 trisodium phosphate, 123
 collagen, 193
 fish collagen, 193
 frozen poultry, 301
 glycerin, 193
 grading, 193
 hot water, 125
 intestines, 193
 irradiation, 125
 modified atmospheres, 124, 333
 pork skin, 193
 sorting, 193, 202
 vacuum, 124
 Pain, 195, 197, 198
 Pale, soft, exudative (PSE), 63, 237, 460
 Pareve (parve, parev), 143, 145, 150, 153, 154, 161, 162
 Pas Yisroel, 152
 Passover, 136, 147, 148, 149, 152, 158, 162
 Pathogen specificity, 30
 Pathogenic worms, 187
Taenia solium, 187
Trichinella spiralis, 187
 People of the Book, 195
 Pepsi, 159
 Permissible, 184, 187, 194
 Pesticides, 634–636, 725
 “farmer’s lung”, 635
 meat and eggs contamination, 636
 organochloride compounds, 636
 poultry feed, 634
 roentgenography, 635
 toxicity, 635
 Phytosterols, 564
 Pigs, 190, 200, 206, 207
 pig scare, 213
 Pogem, 150
 Poisonous, 190, 191, 207
 Pork, 184, 186, 187, 191, 193, 194, 212
 Positioning in processing, 760
 Poultry food handlers, guidance, 749
 Poultry meat, 467, 479, 481, 483
 Poultry processing and workers’ safety, *see*
 Workers’ safety in poultry processing

Prerequisite programme (PRP), 668, 672
 operational prerequisite programme (OPRP), 668, 680
 Principles, 186, 187, 204, 205
 Probiotics, 24
 conventional probiotics, 24
 probiotics of poultry origin, 26
 Prohibited, 184, 186–189, 191, 211, 214
 Prohibition, 186, 212
 Prophet Muhammad, 184, 187–189, 197
 Proteins, 468, 472
 amino acids, 472, 473, 474, 475
 antifreeze proteins, 350, 365, 368–369
 collagen, 495
 cryoprotectants, 252
 denaturation, 251, 517–518
 digestibility, 472, 475
 effect of ionic strength, 252
 myofibrillar, 492–493, 495, 517
 myosin, 517
 nutritional value, 472
 PDCAAS, 475
 PER, 474, 475
 quality, 473
 sarcoplasmic, 517–518
Pseudomonas, 315, 723
Psychrobacter, 315
Qiyas 184
 Quality, 188, 193, 195, 206, 214, 215, 268
 Quran, 155, 184, 188, 189, 196, 213
 Rabbi I. Grunfeld, 133
 Rabbi Joseph Karo, 133
 Rabbi Moses Isserles, 133
 Raw materials, 191–193, 210, 298
 Recombinant DNA, 190
 Recommendations, 197, 204
 Refrigeration and freezing, 264–265, 276, 283, 300, 326, 398, 518, 523–524
 applications, 403
 cooling medium (secondary refrigerant), 351–354
 cooling system, 350–357
 display cases and cabinets, 382–385
 air flow patterns, 385
 insulation, 386
 relative humidity, 385
 shelf-life in, 386–387
 store parameters, 387
 energy definition, 283
 food services, 399, 407–410
 general guidelines, 410–411
 heat, definition, 283

heat exchange, 284
 freezing and frozen storage, 244, 264, 265, 269, 276, 294, 350, 380, 402–405
 batch operating, 351, 354, 357, 358, 360, 362
 chemical deterioration, 244
 continuous operating, 351, 354, 358, 360, 362
 crystal formation, 266, 285
 darkening effect, 286
 equipment, 352–357
 extracellular changes, 266
 freezing definition, 284
 freezing temperature, 285
 high-pressure freezing, 350, 365
 high-pressure assisted freezing (PAF), 366
 high-pressure shift freezing (PSF), 350, 366
 innovations in freezing operations, 365–370
 installations, 357–363
 methods, 265–266, 285, 380
 novel freezing methods, 365–367
 oxidative effects, 266, 276
 physical changes, 245, 264
 quality indicators of frozen poultry, 294
 selection, 364–365
 temperature, 244
 kinetic behavior, 289
 legislation, 411–412
 ready-to-eat, 400
 refrigerant (primary refrigerant), 351–362
 refrigeration, 264–265, 276, 288, 327, 378–380, 311, 402–405
 costs, 343
 definition, 284
 direct systems, 378
 distribution, 379
 effect on enzymatic activity, 269
 effect on meat quality, 311
 equipment and installations, 327–343, 402–405, 410
 indirect systems, 379
 modified atmosphere, 333
 principles, 379–380
 refrigerants, 288
 refrigeration cycle, 276
 refrigeration load, 288
 storage, 311, 337–340, 341–342
 restaurants, 398, 406–407
 retail stores, 378
 wrapping, 382
 Religious, 185, 188, 190–192, 200, 204
 Reports, 115

Requirements, 108, 109, 110, 111, 112, 116, 117, 118, 185, 194, 197, 199–201, 205–209, 211
 food business operator, 108
 official control, 108
 Responsibilities
 food business operator, 108
 official control, 108
 Restraining, 198
 Restriction, 184, 198, 204
 Rigor mortis, 492–494
 Ritual cleansing, 193, 192
dibagh, 193, 194, 209
 Rokeach, 149
 Rotation strategies in processing, 761
 Royal Jelly, 138
 Ryanodine receptor (RyR), 518–520
 Sabbath, 141
 Sabbath year, 152
 Safe, 187, 189, 209, 212
 Safeguard, 187, 189
Salmonella, 30, 315, 644, 648, 649, 650, 651, 705, 706, 707, 718, 720, 723, 724, 729, 730, 731
Salmonella enteritidis, 705
Salmonella heidelberg, 705, 709
Salmonella infantis, 711
Salmonella typhimurium, 709, 712
 Scalding, 198, 201–203
 Scales
 ctenoid, 137
 cycloid, 137
 ganoid, 137
 placoid, 137
 Sensory, 496, 505–510
 Sephardic Jews, 140, 149
 Septicemia, 684
 Shariah, 184, 188–191, 193, 195–198, 206–211, 214
 Shechitah, 168, 170
 Shellac, 137, 138, 143
 Shi'a, 184, 206
Shigella, 728
Shirk, 186, 187
 Shochet, 138, 139, 156, 167, 170, 171, 174
 Shulchan Aruch, 133
 Sirkas, 140
 Slaughterer, 195, 196
aqil, 195
baligh, 195
 mature, 195
 mentally sound, 195, 208
mumayyiz, 195

Slaughterer (*contd.*)
People of the Book, 195
Slaughtering and evisceration, 45–51, 72–77, 183, 184, 186, 191, 194–202, 204, 205, 207, 208, 214, 493–494, 721
bleeding, 75, 198, 201, 207, 208, 214
blood vessels, 196
building requirements, 72
carcass washer, 96
chillers, 75
cutting and packaging, 75
deboning, 493–494
defeathering or plucking, 94, 721
equipment and machinery, 74, 76, 90, 95
head and trachea puller, 74, 95
hygiene and safety of personnel, 77
killing, 196, 197
live animal reception, 73
plants, 74, 80
premortem handling, 45–51
sanitary specifications, 72
scalders, 93
stabbing, 196
storage rooms, 75
sourcing, 191
waste disposal, 76
Spinal cord, 196
Spirit of humane, 140
Standard industrial classification system, 738. *See also* North American industrial classification system standards, 184, 189, 193, 197, 199, 200, 203–205, 207, 209, 211, 214
Staphylococcus, 718, 723, 728, 730
Star-K, 159
Starving, 198
Status, 184, 189, 191, 192, 194, 197, 205
Storage, 191, 192, 194, 203, 205, 206, 209, 210, 211, 214
Stress, 45–51, 198, 202, 518–519, 522, 720
Stunning, 74, 80, 184, 198–200, 203, 208, 215
amperage, 199
current, 192, 198–200
electrical stunning, 199, 200
reversible, 200
shackling, 198
voltage, 199
water bath, 198, 199
Suffering, 195, 198
Sunni, 184, 206
Superfluous, 186, 187
Surah, 188, 189, 196

INDEX

Taam, 151
Takbir, 156
Talmud, 133, 144
Tasks in processing, 763
TBT (technical barriers to trade), 203
Ten Commandments, 133
Tenets, 185
Texture, 252, 264, 268–269, 296, 313, 459–462, 496, 499, 505–511
age and, 459
boning method and, 461–462
cell structure damage, 253
effect of temperature, 269
feed and, 460
frozen poultry, 296
heat and, 462
measurement methods, 269
MIRINZ, 272
Meullenet-Owens razor shear (MORS), 498, 501–504, 508–509
multiblade Kramer, 270
sample weight, 270
spectral stress strain analysis, 510
texture profile analysis, 273, 498, 501–502, 507–508
Volodkevich, 272
Warner-Bratzler, 270, 496–498, 507–509
myofibrillar proteins, 252
pale, soft, exudative (PSE) and, 460
sensory evaluation, 239, 274
shear value, 253
stunning and, 461
Tenderness, 253, 492–495, 509
Thawing, 245
cell disruption, 246
effects on meat structure, 245
ice crystals, 245
shear force changes, 246
temperature changes, 245
Thiamine degradation, 274
Thoyyib, 188, 189, 195
Thrips, 138
Throat, 195, 196, 200
Torah, 133, 137, 138, 143
Toxemia, 684
Trachea, 196, 197, 201, 202, 207, 208
Transportation, 49, 191, 192, 194, 198, 206, 209, 210, 523
Treiboring, 141, 149
Treife, 139, 150
Tsar Baalay Chayim, 168

INDEX

Ulama', 195
Unconsciousness, 198
Union of Orthodox Jewish Congregations, 159
Unit operations, 191–193, 378
U.S. Government
Code of Federal Regulations, 163
Congress, 139
Department of Agriculture (USDA), 168
FDA, 157
Federal Court of Appeals for the Second District, 163
Federal District Court for Eastern New York, 163
Supreme Court, 163
U.S. Poultry Inspection Program, 683
evisceration line systems, 684
HACCP (hazard analysis and critical control point) systems, 684
HIMP (HACCP-based inspection models project), 684
organoleptic inspection, 684
Verse, 188, 196
Visual death, 203
Vitamins, 471, 482, 555
niacin, 484
pyridoxine, 483
Wadajain 196, 201, 207, 208
Warehouses, 194
Water, 190, 193, 198–200, 203, 207, 209
Water activity, 425
Water holding capacity, 426, 493, 495, 516–517, 524–526, 636
Weight loss, 314
WHO (World Health Organization), 204
Wholesomeness, 188
Workers' health and safety, poultry processing, 738, 741
avian influenza or bird flu, 743
guidance for food handlers, 749
infection control measures, 745
psittacosis, 741
Worship 187, 188
Yashon, 147
Yersinia enterocolitica, 315, 723

A comprehensive reference for the poultry industry—Volume 1 describes everything from husbandry up to preservation

With an unparalleled level of coverage, the *Handbook of Poultry Science and Technology* provides an up-to-date and comprehensive reference on poultry processing. *Volume 1* describes husbandry, slaughter, preservation, and safety. It presents all the details professionals need to know beginning with live poultry through to the freezing of whole poultry and predetermined cut parts. Throughout, the coverage focuses on one paramount objective: an acceptable quality and a safe product for consumer purchase and use. The text includes safety requirements and regulatory enforcement in the United States, EU, and Asia.

Volume 1: Primary Processing is divided into seven parts:

- **Poultry: biology to pre-mortem status**—includes such topics as classification and biology; competitive exclusion; transportation to the slaughterhouse; and more
- **Slaughtering and cutting**—includes the slaughterhouse building and required facilities; equipment; and operations; carcass evaluation and cutting; kosher and halal slaughter; and more
- **Preservation: refrigeration and freezing**—includes the biology and physicochemistry of poultry meat in rigor mortis under ambient temperature, as well as changes that occur during freezing and thawing; engineering principles; equipment and processes; quality; refrigeration and freezing for various facilities; and more
- **Preservation: heating, drying, chemicals, and irradiation**
- **Composition, chemistry, and sensory attributes**—includes quality characteristics; microbiology; nutritional components; chemical composition; and texture of raw poultry meat
- **Eggs**—includes egg attributes, science, and technology
- **Sanitation and Safety**—includes PSE, poultry-related foodborne diseases, OSHA requirements, HACCP and its application, and more

ISABEL GUERRERO-LEGARRETA, PhD, the Editor, is Professor in the Biotechnology Department at the Universidad Autónoma Metropolitana in Mexico. She has expertise in the meat and poultry sciences; and she has published over eighty manuscripts, five books, and twenty-nine book chapters.

Y.H. HUI, PhD, the Consulting Editor, is the Senior Scientist at Science Technology System and has been the author or editor of many books on food science and technology.

Subscribe to our free Chemistry eNewsletter at
wiley.com/enewsletters

Visit wiley.com/chemistry

 **WILEY**
wiley.com

ISBN 978-0-470-18552-0

90000



9 780470 185520