Contents

List of Contributors xiii Foreword by Ping-fan Rao xv Foreword by Matilda Freund xvii Preface xix Nomenclature xxiii

1 Fundamentals in Management of Food Safety in the Industrial Setting: Challenges and Outlook of the 21st Century YASMINE MOTARJEMI, HUUB LELIEVELD

Consumer Trust: The Corner Stone of a Food Business 2 The 21st Century: A New Era in Food Safety 2 The Concept of Food Safety and its Definition 3 Elements of Food Safety Management 4 Challenges in Management of Food Safety and Outlook 11 Conclusions 19 References 19 Further Reading 20

Ι

RISKS AND CONTROLS IN THE FOOD SUPPLY CHAIN

2 Management of Safety in the Feed Chain

ARNAUD BOUXIN

Overview of the Feed Chain 24

Characteristics of the Feed Chain 24

Potential Hazards 28

Good Hygiene Practices in the Feed Sector 34 Examples of Feed Safety Incidents and What Lessons Can be Learned 39 Conclusions 43 References 43

3 Naturally Occurring Toxicants of Plant Origin

BENOÎT SCHILTER, ANNE CONSTABLE, IRÈNE PERRIN

Introduction 45

Scope and Definitions 46

Inherent Plant Toxicants: Chemical Diversity and Roles in the Plants 47 Toxicological and Biological Considerations 47

Risk Assessment Considerations 52

Risk Management of Inherent Plant Toxicants 53 Conclusions 55

References 56

4 Allergens

RENÉ CREVEL, STELLA COCHRANE

Introduction 60 Food Allergy: A Public Health Problem 60 Allergenic Foods of Public Health Importance, 65 Management of Food Allergens 67 Analytical Aspects of Allergen Management 75 Summary 80 References 81

5 Milk and Dairy Products

YASMINE MOTARJEMI, G.G MOY, P.J. JOOSTE, L.E. ANELICH

Introduction 84 Historical Perspective 85 Foodborne Disease Outbreaks 86 Risk and Controls 90 Conclusion 114 References 115 Further Reading 116

v

6 Meat and Meat Products JOHN N. SOFOS

Introduction 120
Hazards Associated with Meat and Meat Products 121
Contamination Frequency and Incidence of Disease 134
Control of Hazards at Different Stages of the Meat Chain 140
Meat Safety Process Management 148
Conclusions 158
References 158
Further Reading 159

7 Poultry and Eggs

SHAI BARBUT, IRWIN PRONK

Introduction 163 Microbial Hazards 164 Chemical Hazards 166 Physical Hazards 167 HACCP Generic Model 167 Importance of Equipment/Process Selection 175 Advantages of Implementing HACCP 177 Egg Breaking Operations 180 References 186

8 Seafood

SANJA VIDAČEK

Introduction 190 Production of Safe Seafood – Prerequisite Programs and HACCP 191 Hazards Associated with Seafood 193 Risks at Different Stages of the Food Chain 205 Conclusion 210 References 210

9 Fruits and Vegetables (including Herbs) VLASTA PILIŽOTA

Introduction 214 Food Safety 215 Hazards Associated with Fruits and Vegetables (Including Herbs) 215 Factors Affecting Biological Contamination 217 Contamination Along the Food Chain 220 Control Measures in Preventing Contamination 226 Application of the HACCP System 232 A Case Study on the Application of the HACCP Approach for the Management of the PrepAration of Fresh Tomatoes for Storage and Sale 233 Conclusion 247 Acknowledgment 248 References 248

10 Coffee, Cocoa and Derived Products (e.g. Chocolate) ANETT WINKLER

General Considerations 252 Cocoa and Derived Products 259 References 280 Further Reading 282

11 Honey, Confectionery and Bakery Products SUCHART CHAVEN

Introduction 284 Honey 284 Confectionery 289 Bakery 292 Concluding Remarks 298 References 298 Further Reading 299

12 Edible Nuts, Oilseeds and Legumes

Part 1: Perspectives on Mycotoxins W.C.A. GELDERBLOM, G.S. SHEPHARD, J.P. RHEEDER, S.K. SATHE

Part 2: Pistachio Nut Processing HACCP Study A. GHIASI, Y. MOTARJEMI, J.P. RHEEDER

Part 1: Perspectives on Mycotoxins 302 Part 2: Pistachio Nut Processing HACCP Study 312 Acknowledgments 322 References 322 Further Reading 324

> 13 Oils and Fats GERRIT VAN DUIJN

Introduction 326 Contaminants in Crude Oils and Fats 327 Refining Process Validation for Contaminant Removal 335

vi

By-Products Formed During Oil Refining 341 HACCP 343 References 345

14 Bottled and Drinking Water

ARNOLD F. DIJKSTRA, ANA MARIA DE RODA HUSMAN

Water and the Food Industry 348 Definitions for Water 348 Legislation 349 Sources of Water 350 Drinking-water Applications in the Food Industry 354 Hazards Associated with Drinking Water 358 Risk Assessment and Risk Management 366 HACCP Case Studies 367 References 376 Further Reading 377

15 Pet Food

PABLO A. CARRIÓN, LARRY J. THOMPSON

Introduction 379 Biological Hazards 380 Mycotoxicosis 384 Toxicities Caused by Medicated Feed Carry-over into Pet Food Raw Materials 388 Adulteration for Profit, the Melamine Case 389 Toxicities Caused by Nutrient Misformulation 391 Conclusion 391 References 393

16 Food Contact Materials

CARLOS DE LA CRUZ GARCIA, GLORIA SÁNCHEZ MORAGAS, DAVID NORDQVIST

Introduction 397 Definitions 398 Classification of Materials 400 Hazard Identification 405 Management of Safety of Food Contact Materials 410 Recycling and Reuse 413 The Potential Environmental Impact 413 Lessons from Case Studies 414 Annex 416 References 418 Further Reading 419

II

TECHNOLOGIES AND FOOD SAFETY

17 Thermal Treatment TIBOR DEAK

Introduction 423
Heat Processing 424
Fundamentals of Thermal Death of Microorganisms 425
Heat Resistance of Microorganisms 426
Determination of Heat Process Requirement 428
Conventional Heat Preservation 432
Factors Determining Heat Treatment 437
Non-Traditional Heat Treatment 438
Combined Treatments 440
References 441

18 Non-thermal Processing Technologies

OLGA MARTÍN-BELLOSO, ROBERT SOLIVA-FORTUNY, PEDRO ELEZ-MARTÍNEZ, A. ROBERT MARSELLÉS-FONTANET, HUMBERTO VEGA-MERCADO

Introduction: Identification of Risks in Non-Thermal Processes 444 Non-Thermal Treatments for Food Preservation 447 Verification and Validation Methods for Non-Thermal Technologies 462 Final Remarks 463 References 463

19 Acids and Fermentation MARTIN R. ADAMS

Introduction: Acidity and pH 467 Acidity and Foods 470 Acidity and Microorganisms 471 Control of Pathogens by pH and Acidity 472 Fermented Foods 474 Food Safety Problems with Acidic Foods 475 Conclusions 478 References 478 Further Reading 479

20 Chilling and Freezing STEPHEN J. JAMES, CHRISTIAN JAMES

Introduction 482 Effect of Chilling on Food Safety 483 Effect of Chilling Rate on Food Safety 484 Effect of Freezing on Food Safety 486 Effect of Freezing Rate on Food Safety 488 Chilling and Freezing Principles 488 Chilling/Freezing Methods/Equipment 489 Thawing and Tempering Systems 497 Transportation 498 Chilled Retail Display 498 Frozen Retail Display 499 Domestic Handling 500 Specifying Refrigeration Systems 501 Managing/Production Principles for Refrigerated Foods 503 Temperature Measurement and Monitoring 503 References 508 Further Reading 509 Relevant Websites 510

21 Detection of Physical Hazards GILLES DEMAUREX, LAURENT SALLÉ

Introduction 511 Sorters and Detection Equipment (Figure 21.1) 512 Metal Detection 515 X-Ray Detection 518 Equipment Selection 524 Detection Equipment Management 528 Further Reading 533

III

FOOD SAFETY ASSURANCE SYSTEMS

22 Principles and Systems for Quality and Food Safety Management PETER OVERBOSCH, SARAH BLANCHARD

Principles, Systems and Schemes 538 Principles and Associated Systems 541 Integrated Schemes and Their Limitations 552 The Future of Systems 556 Further Reading 557

23 Hygiene in Primary Production GISELA KOPPER, SLAVKO MIRECKI, IGOR S. KLJUJEV, VERA B. RAICEVIC, BLAZO T. LALEVIC, JELENA JOVICIC-PETROVIC, STOJMIR STOJANOVSKI, DIJANA BLAZEKOVIC-DIMOVSKA Introduction 561 Part 1: Good Animal Husbandry 566 Potential Health Risks on Animal Farms 566 Foodborne Diseases 566 Examples of Foodborne Pathogens 567 Good Farming Practices for Animal Husbandry 573 Animal Health 575 Principles of Biosecurity 576 Good Hygiene Practices on the Livestock Farms 579 Hazard Analysis and Critical Control Points 586 Part 2: Good Agricultural Practices for Food Safety 586 Sources of Microbiological Contaminations of Fresh Vegetables 587 Microbiological Quality of Irrigation Water 588 Presence of Pathogenic Bacteria on Fresh Vegetables 588 Transmission of Pathogenic Bacteria from Contaminated Irrigation Water and Soil to Plants 589 Good Agricultural Practices 591 Part 3: Fish Hygiene 596 Disease Prevention 596 Disease Treatment 597 Major Fish Diseases 600 Diseases of Mollusca and Crustacea 606 Fish Toxicity 607 Pathogenic Bacterial Growth and Toxin Formation 615 References 618

24 Hygiene in Food Processing and Manufacturing

JOHN HOLAH

Introduction 624 Prerequisite Management Plan 628

viii

Recommended Procedure for Developing a Processing Environment Plan 643 Future Studies 656 References 657 Further Reading 659

25 Site Selection, Site Layout, Building Design HUUB LELIEVELD

Introduction 662 Regulatory Requirements 662 Retailer's Requirements 663 Site Selection 663 Site Layout 664 Building Design 665 References 672 Further Reading 672

26 Hygienic Design and Maintenance of Equipment

FRANK MOERMAN, JACQUES KASTELEIN

Introduction 674
Legislation 675
Basic Hygienic Requirements 675
Materials of Construction 678
Surface Finish 682
Hygienic Design of Open Equipment for Processing of Food 682
Hygienic Design Closed Equipment for Processing of Liquid Food 710
Installation of the Food Processing Equipment in the Food Factory 729
Hygiene Practices During Maintenance Operations in the Food Industry 730
Acknowledgment 738
References 738

27 Development of a Comprehensive Cleaning and Sanitizing Program for Food Production Facilities ROBERT RYTHER

Introduction: Cleaning and Sanitizing Operations in Food Processing Facilities 742 CIP Background (Figure 27.1) 744 COP Cleaning 747 Environmental Cleaning 748 Cleaning of Allergens 749 Cleaning of Dry or Low Moisture Foods 750 Cleaning Chemistry 750 Common Cleaning Problems in Food Process Environments 754 Sanitizing Chemistry 756 Application of Sanitizers in Food Processing Facilities 761 Cleaning Validation and Verification Technology 761 Conclusions 766 References 767

28 Personal Hygiene and Health EWEN C.D. TODD

Risks of Outbreaks Associated from Infected Food Workers 770
Factors Contributing to Outbreaks 772
Examples of Outbreaks Caused By Food Workers 772
Pathogens Carried by Food Workers 774
Hygienic Practices of Food Workers 775
Practical Aspects of Hand Hygiene 781
Barriers in Food Operations to Limit Spread of Pathogens 787
Exclusion of Infected Employees to Work in Specific Food Operations 792
Conclusion 795
References 796
Further Reading 798

29 Pest Management

CHRISTOPHER H. BELL

Introduction 800
Pests of Food Processing and Production Facilities and the Risks they Impose 800
Minimizing Pest Occurrence in Food Premises 807
Pest Detection Strategies 808
Pest Control Strategies 811
Emerging Threats for the Successful Maintenance of Pest Management 817
References 818 CONTENTS

30 Safe Handling of Food in Homes and Food Services PATRICIA DESMARCHELIER

Introduction 821 Evidence of Foodborne Illness and Consequences 822 Food Safety Hazards 824 Food Safety Risk Factors 824 Food Safety Management 825 Application of HACCP Principles to Food Service and the Home 826 Prerequisite Programs 827 Hazard Analysis 832 Education and Training 840 Conclusions 841 References 842

31 Hazard Analysis and Critical Control Point System (HACCP) YASMINE MOTARJEMI

Introduction 845 Historical Background 847 The Need for HACCP 848 Principles of the HACCP System 849 Application of HACCP 850 HACCP in Small Businesses or Less Developed Business 869 Assessment of HACCP 869 Conclusion 870 References 871 Further Reading 871

32 HACCP Misconceptions

YASMINE MOTARJEMI, CAROL WALLACE, SARA MORTIMORE

Introduction 873 Misconceptions 874 Common Errors or Shortcomings in the Application of HACCP 878 Conclusions 886 References 887 Further Reading 887

33 Management of Microbiological Hazards: Role of Testing as Verification TIM JACKSON

Introduction 890 When are Microbiological Testing Programs Useful for Verification? 891 Prerequisites to the Development and Implementation of Microbiological Testing Programs 894 Microbiological Monitoring of the Factory Environment 898 Acceptance Criteria and Testing Programs for Finished Products and Raw Materials 909 Microbiological Monitoring of Raw Materials 910 Microbiological Monitoring of Finished Products 913 Root Cause Analysis and Corrective Actions 915 References 915 Further Reading 917

34 Management of Chemical Contaminants YASMINE MOTARIEMI

Introduction 920
Nature of Chemical Hazards 920
Health Consequences 921
Factors Affecting the Occurrence of Chemical Hazards 921
Regulatory Requirements and Challenges 922
Regulatory Compliance 923
Management of Chemicals in Industry 923
Application of the HACCP System to Management of Chemicals 927
Further Reading 935

35 Food Defense

NED MITENIUS, SHAUN P. KENNEDY, FRANK F. BUSTA

Description of Issues 938 Definitions for Food Defense and Related Terms 938 Farm to Fork 940 Types of Risk and Hazards 941 Methods of Vulnerability Analysis 945 Preventive Measures 950

х

How to Manage the Case 956 Food Recall Case Studies 957 References 957

36 Effective Leadership SERGE IMBODEN

Introduction 959 Theories on the Subject of Leadership 961 Models of Effective Leadership 962 Final Remarks 972 References 973

> 37 Human Factors in Food Safety Management YASMINE MOTARJEMI

Introduction 975 Swiss Cheese Concept 978 Root Cause of Failures 979 Management Commitment 984 Conclusions 985 References 986

38 Assessment of Food Safety Management Systems YASMINE MOTARJEMI, SARA MORTIMORE

Introduction 987 Background 988 Definition and Purpose 989 Scope and Frequency of Assessments 989 Competence of Assessors 994 The Procedure and Methodology 995 The Development and use of a Checklist 1000 Conclusions 1003 Acknowledgment 1004 Further Reading 1004

39 Consumer Information and Labeling

marjana peterman, tanja pajk žontar

Introduction 1005 Who is the Consumer? 1006 Consumer Protection 1007 Global Regulatory Measures 1007 Consumer Choice, Information and Education 1008 Clear and Legible Label, a Legal Requirement 1009 Product Information Within a Food Chain 1009 Consumer and Risk 1011 Labeling of Allergens 1012 Precaution 1013 Labeling "May Contain" 1014 Consumer Feedback 1014 Discussion for the Future 1015 References 1015 Further Reading 1016

40 Incident Management and Root Cause Analysis

YASMINE MOTARJEMI, CAROL A. WALLACE

Introduction 1017 Prevention of Incidents 1018 Reporting an Incident 1020 Managing an Incident 1020 Investigation 1022 Root Cause Analysis 1023 Conclusions 1035 References 1036 Further Reading 1036

41 Crisis Management YASMINE MOTARJEMI Introduction 1037

What is a Crisis? 1038 What did we Learn from our Crises? 1040 What Lessons for the Future? 1051 Essentials of Crisis Management 1051 Conclusions 1062 References 1062 Further Reading 1063

42 The Role of International, Regional and National Organizations F. TRACY SCHONROCK

Introduction 1065 Leading International Standards Organizations 1067

CONTENTS

Leading Regional Standards Organizations 1071 Leading National Governmental Organizations 1073 Leading Industry Organizations 1075 Leading Hygienic Design Standards Organizations 1079 Conclusions 1081 Further Reading 1082

IV

SUSTAINABILITY AND ETHICS

43 Sustainability and Food Production THOMAS OHLSSON

Introduction 1085
Sustainability – an Introduction 1086
Social Aspects of Sustainability and Food Production 1087
Economic Aspects of Sustainability and Food Production 1088
Environmental Concerns Related to Food Production 1089
Improving Sustainability in the Food Sector 1092
Food Safety and Sustainability 1093
Sustainability and Food Production in the Future 1094
References 1096 44 Climatic Changes YASMINE MOTARIEMI

Introduction 1099 Impact of Climate Change on Food Safety 1100 Conclusion 1101 Further Reading 1101

45 Nutritional Trends and Health Claims JEAN-MICHAEL ANTOINE

Introduction 1103 Historical Perspective 1104 Modern Times 1106 Foods for Health 1107 Diet and Health 1107 References 1113

46 Ethics in Food Safety Management NINA VEFLEN OLSEN, DIÁNA BÁNÁTI

Introduction 1115 What is Ethics? 1116 Ethical Issues in Food Safety 1118 Ethical Decision-Making 1122 Conclusion 1123 References 1124

> 47 Training and Education YASMINE MOTARJEMI, HUUB LELIEVELD

Reference 1130

Index 1131

xii