

International Commission
on Microbiological Specifications
for Foods (ICMSF)

Microorganisms in Foods

8

Use of Data
for Assessing Process Control
and Product Acceptance

 Springer

International Commission on Microbiological Specifications
for Foods (ICMSF)

Microorganisms in Foods 8

Use of Data for Assessing Process Control
and Product Acceptance

International Commission on Microbiological Specifications for Foods (ICMSF)
Katherine MJ Swanson, editorial committee chair

ISBN 978-1-4419-9373-1 e-ISBN 978-1-4419-9374-8
DOI 10.1007/978-1-4419-9374-8
Springer New York Dordrecht Heidelberg London

Library of Congress Control Number: 2011928066

© Springer Science+Business Media, LLC 2011

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC, 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden. The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

Preface.....	xiii
Contributors and Reviewers.....	xv
Abbreviations.....	xix
Part I Principles of Using Data in Microbial Control	
1 Utility of Microbiological Testing for Safety and Quality	3
1.1 Introduction	3
1.1.1 Testing as Part of a Food Safety Management Program.....	4
1.1.2 Principles of Microbiological Testing and Definitions.....	5
1.1.3 Utility Microorganisms, Indicators or Pathogens	5
1.1.4 Risk Based Sampling Using ICMSF Cases	6
1.2 GHP and HACCP	7
1.2.1 Validation of Control Measures	7
1.2.2 Verification of Process Control.....	8
1.2.3 Verification of Environmental Control.....	8
1.2.4 Corrective Action to Reestablish Control	9
1.2.5 Microbiological Testing in Customer-Supplier Relations	9
1.2.6 End Product Testing to Evaluate Integrity	10
1.3 Limitations in Microbiological Testing of Foods.....	10
1.4 Conclusions	11
References.....	11
2 Validation of Control Measures.....	13
2.1 Introduction	13
2.1.1 Relationship of Validation to Monitoring and Verification.....	13
2.2 Considerations for Validation	15
2.3 Validation of Control Measures.....	16
2.3.1 Initial Level (H_0), Standard Deviation and Distribution.....	16
2.3.2 Inactivation Studies (ΣR).....	18
2.3.3 Growth Studies (ΣI)	21
2.3.4 Recontamination (ΣI).....	23
2.4 Effect of Process Variability on FSO Compliance Validation.....	24
2.4.1 Point Estimate Approach	24
2.4.2 Including Variability in the Process	24
2.4.3 Log Mean Value, Standard Deviation and Meeting the FSO.....	28
2.5 Validation of Cleaning and Other GHP Control Measures	29

2.6	Shelf Life Determination.....	30
2.7	When to Revalidate.....	31
	References.....	31
3	Verification of Process Control	33
3.1	Introduction	33
3.2	How to Verify that a Process is Under Control	35
3.2.1	Information Required to Establish a Process Control Testing Program	35
3.2.2	Setting Microbiological Criteria, Limits and Sampling Plans	36
3.3	Routine Data Collection and Review	37
3.4	Competent Authority Process Control Program Examples	38
3.4.1	Meat and Poultry.....	38
3.4.2	Juice	39
	References.....	40
4	Verification of Environmental Control.....	41
4.1	Introduction	41
4.2	Establishing an Environmental Control Program.....	41
4.2.1	Step A: Determine the Microorganisms of Concern.....	42
4.2.2	Step B: Determine the Relevant Test Microorganism	43
4.2.3	Step C: Review Measures to Prevent Ingress	43
4.2.4	Step D: Review Other Hygiene Control Measures and Their Impact.....	43
4.2.5	Step E: Review Historical Data	43
4.2.6	Step F: Perform Investigative Sampling.....	43
4.2.7	Step G: Develop Sampling Programs	44
4.2.8	Step H: Define Sampling Frequencies	44
4.2.9	Step I : Establish a Plan for Data Evaluation	44
4.2.10	Step J : Establish a Plan of Action to Respond to Findings	45
4.2.11	Step K: Periodic Review of Sampling Programs	45
	References.....	45
5	Corrective Actions to Reestablish Control	47
5.1	Introduction	47
5.2	Good Hygiene Practices	47
5.3	HACCP.....	48
5.4	Assessing Control of GHP and the HACCP Plan.....	49
5.4.1	Assessing Control of GHP	49
5.4.2	Assessing Control of the HACCP Plan.....	50
5.5	Corrective Actions.....	51
5.5.1	Corrective Actions for GHP.....	51
5.5.2	Corrective Actions for HACCP.....	52
5.5.3	Response to Epidemiologic Evidence and Complaints	52
5.6	Options for Disposition of Questionable Product	53
5.6.1	Sub-Lot Testing Considerations.....	53
5.7	Repetitive Loss of Control.....	54
	References.....	54
6	Microbiological Testing in Customer–Supplier Relations.....	55
6.1	Introduction	55
6.1.1	Raw Materials and Ingredients Used by Manufacturers.....	56

6.1.2 Interactions with Retailers	58
6.1.3 Contract Manufacturers	58
6.2 Auditing.....	59
6.3 Microbiological Data.....	59
References.....	60

Part II Application of Principles to Product Categories

7 Applications and Use of Criteria and Other Tests	63
7.1 Introduction	63
7.2 Format of Product Chapters	64
7.2.1 Primary Production	64
7.2.2 Ingredients	64
7.2.3 In-Process	64
7.2.4 Processing Environment.....	65
7.2.5 Shelf Life.....	65
7.2.6 End Product.....	66
7.2.7 Relative Importance of Tests Recommended	66
7.3 Choice of Microorganisms or Products Thereof	66
7.4 Selection of Limits and Sampling Plans	67
7.4.1 Comparing ICMSF Cases to Codex Criteria for <i>L. monocytogenes</i>	68
7.5 Limitations of Microbiological Tests	71
7.5.1 Analytical Method.....	72
7.5.2 Analytical Units and Compositing	72
References.....	72
8 Meat Products	75
8.1 Introduction.....	75
8.2 Primary Production.....	76
8.3 Raw Meat Products, Excluding Comminuted Meats.....	76
8.4 Raw Comminuted Meats	80
8.5 Raw Cured Shelf-Stable Meats.....	82
8.6 Dried Meat Products.....	84
8.7 Cooked Meat Products.....	86
8.8 Fully Retorted Shelf-Stable Uncured Meats.....	90
8.9 Shelf-Stable Cooked Cured Meats.....	90
8.10 Snails.....	91
8.11 Frog Legs.....	92
References.....	92
9 Poultry Products	95
9.1 Introduction	95
9.2 Primary Production	95
9.3 Raw Poultry Products.....	96
9.4 Cooked Poultry Products.....	100
9.5 Fully Retorted Shelf-Stable Poultry Products	103
9.6 Dried Poultry Products	104
References.....	105

10	Fish and Seafood Products	107
10.1	Introduction	107
10.2	Raw Finfish of Marine and Freshwater Origin	108
10.3	Frozen Raw Seafood	111
10.4	Raw Crustaceans	113
10.5	Cooked Crustaceans	115
10.6	Raw Mollusca	117
10.7	Cooked, Shucked Mollusca	119
10.8	Surimi and Minced Fish Products	121
10.9	Lightly Preserved Fish Products	123
10.10	Semi-Preserved Fish Products	125
10.11	Fermented Fish Products	127
10.12	Fully Dried or Salted Products	129
10.13	Pasteurized Seafood Products	129
10.14	Canned Seafood	131
	References	132
11	Feeds and Pet Food	135
11.1	Introduction	135
11.2	Processed Feed Ingredients	135
11.3	Unprocessed Feeds	138
11.4	Compounded Feeds	140
11.5	Pet Foods, Chews and Treats	141
	References	144
12	Vegetables and Vegetable Products	147
12.1	Introduction	147
12.2	Primary Production	147
12.3	Fresh and Fresh-Cut, Minimally Processed Vegetables	153
12.4	Cooked Vegetables	157
12.5	Frozen Vegetables	161
12.6	Canned Vegetables	164
12.7	Dried Vegetables	164
12.8	Fermented and Acidified Vegetables	166
12.9	Sprouted Seeds	168
12.10	Mushrooms	171
	References	174
13	Fruits and Fruit Products	177
13.1	Introduction	177
13.2	Primary Production	178
13.3	Fresh Whole Fruits	179
13.4	Fresh-Cut, Minimally Processed Fruits	182
13.5	Frozen Fruits	186
13.6	Canned Fruits	188
13.7	Dried Fruits	188
13.8	Tomatoes and Tomato Products	190
13.9	Fruit Preserves	192
	References	193

14	Spice, Dry Soups and Asian Flavorings	197
14.1	Introduction	197
14.2	Dry Spices and Herbs	197
14.3	Dry Spice Blends and Vegetable Seasonings	200
14.4	Dry Soups and Gravy	202
14.5	Soy Sauce	203
14.6	Fish and Shrimp Sauce and Paste	205
	References	207
15	Cereals and Cereal Products	209
15.1	Introduction	209
15.2	Dried, Raw Grains and Their Flour and Flour-Based Mixes	209
15.3	Raw, Frozen and Refrigerated Dough Products	213
15.4	Dried Cereal Products	215
15.5	Baked Dough Products	217
15.6	Unfilled Pastas and Noodles	219
15.7	Cooked Cereals	221
15.8	Topped or Filled Dough Products	224
	References	224
16	Nuts, Oilseeds, Dried Legumes and Coffee	227
16.1	Introduction	227
16.2	Nuts	227
16.3	Oilseeds	231
16.4	Dried Legumes	232
16.5	Coffee	235
	References	237
17	Cocoa, Chocolate and Confectionery	241
17.1	Introduction	241
17.2	Cocoa Powder, Chocolate and Confectionery	241
	References	245
18	Oil- and Fat-Based Foods	247
18.1	Introduction	247
18.2	Mayonnaise and Dressings	247
18.3	Mayonnaise-Based Salads	250
18.4	Margarine	253
18.5	Reduced-Fat Spreads	256
18.6	Butter	258
18.7	Water-Continuous Spreads	260
18.8	Miscellaneous	260
	References	261
19	Sugar, Syrups and Honey	263
19.1	Introduction	263
19.2	Cane and Beet Sugar	263
19.3	Syrups	265
19.4	Honey	266
	References	268

20	Nonalcoholic Beverages	269
	20.1 Introduction.....	269
	20.2 Soft Drinks.....	269
	20.3 Fruit Juice and Related Products	272
	20.4 Tea-Based Beverages.....	275
	20.5 Coconut Milk, Coconut Cream and Coconut Water.....	277
	20.6 Vegetable Juices.....	278
	References.....	279
21	Water	281
	21.1 Introduction.....	281
	21.2 Drinking Water	281
	21.3 Process or Product Water.....	284
	21.4 Packaged Waters.....	286
	References.....	288
22	Eggs and Egg Products	291
	22.1 Introduction.....	291
	22.2 Primary Production.....	291
	22.3 Shell Eggs.....	292
	22.4 Liquid and Frozen Eggs.....	294
	22.5 Dried Eggs.....	298
	22.6 Cooked Egg Products	299
	References.....	302
23	Milk and Dairy Products	305
	23.1 Introduction.....	305
	23.2 Raw Milk for Direct Consumption	305
	23.3 Processed Fluid Milk	308
	23.4 Cream.....	311
	23.5 Concentrated Milk	312
	23.6 Dried Dairy Products	314
	23.7 Ice Cream and Similar Products	317
	23.8 Fermented Milk	319
	23.9 Cheese.....	322
	References.....	326
24	Shelf-Stable Heat Treated Foods	329
	24.1 Introduction.....	329
	24.2 Significant Organisms.....	329
	24.3 Process Control.....	331
	24.3.1 Packaging Integrity	331
	24.3.2 Heating and Cooling.....	331
	24.3.3 Hygienic Handling of Packs.....	332
	24.4 Microbiological Data.....	332
	References.....	336
25	Dry Foods for Infants and Young Children	339
	25.1 Introduction.....	339

25.2	Powdered Infant Formulae.....	339
25.3	Infant Cereals.....	344
	References.....	347
26	Combination Foods.....	349
26.1	Introduction.....	349
26.2	General Considerations.....	349
26.3	Microbial Data.....	350
26.3.1	Critical Ingredients.....	350
26.3.2	In-Process.....	350
26.3.3	Processing Environment.....	350
26.3.4	Shelf Life.....	351
26.3.5	End Product.....	351
26.4	Topped or Filled Dough Products.....	351
	References.....	354
	Appendix A Sampling Considerations and Statistical Aspects of Sampling Plans.....	355
	Appendix B Calculations for Chapter 2.....	365
	Appendix C ISO Methods Referenced in Tables.....	367
	Appendix D Objectives and Accomplishments of the ICMSF.....	369
	Appendix E ICMSF Participants.....	377
	Appendix F ICMSF Publications.....	383
	Appendix G Sponsors of ICMSF Activities.....	387
	Index.....	389

Preface

ICMSF and the Evolution of Food Safety Management

Microorganisms in Foods 8: Use of Data for Assessing Process Control and Product Acceptance was written by the International Commission on Microbiological Specifications for Foods (ICMSF) with assistance from a limited number of expert consultants. The purpose of this book is to provide guidance on appropriate testing of ingredients, food processing environments, processing lines and finished products to enhance the microbiological safety and quality of the food supply.

ICMSF books represent an evolution in microbiological food safety management principles. In the 1970s and 1980s, food safety control was primarily accomplished through inspection, compliance with hygiene regulations and end product testing. *Microorganisms in Foods 2: Sampling for Microbiological Analysis: Principles and Specific Applications* (1974, 1986) put forward a sound statistical basis for microbiological testing through the use of sampling plans. Sampling plans remain useful at ports of entry when there is no information on the conditions under which a food has been produced or processed.

At an early stage, the Commission recognized that no single sampling plan could ensure the absence of a pathogen in food. This led the Commission to publish *Microorganisms in Foods 4: Application of the Hazard Analysis Critical Control Point (HACCP) System to Ensure Microbiological Safety and Quality* (1988). The value of HACCP for enhancing food safety is recognized globally. *Microorganisms in Foods 4* illustrated the procedures to identify microbiological hazards in food production, to identify the critical points to control the hazards and to establish systems to monitor the effectiveness of control.

Effective implementation of HACCP requires knowledge of hazardous microorganisms and their responses to conditions in foods (e.g., pH, water activity, temperature, preservatives etc.). The Commission's *Microorganisms in Foods 5: Characteristics of Microbial Pathogens* (1996) is a thorough but concise review of the literature on growth, survival and death responses of foodborne pathogens. It is intended as a quick reference to assist in making judgments on the growth, survival or death of pathogens in support of HACCP plans and to improve food safety.

Microbiological food safety management requires an understanding of the microbial ecology of the food being produced. *Microorganisms in Foods 6: Microbial Ecology of Food Commodities* (1998, 2005) is intended for those concerned with the applied aspects of food microbiology. It describes the initial microbiota, pathogen prevalence, effects of processing, spoilage patterns, foodborne illness outbreaks and control measures for 17 food commodities. The updated version of *Microorganisms in Foods 6* builds on *Microorganisms in Foods 7* by identifying controls that influence the initial level, increases, and decreases in the microbial population.

Microorganisms in Foods 7: Microbiological Testing in Food Safety Management (2002) illustrates how HACCP and Good Hygienic Practices (GHP) provide greater assurance of safety than microbiological testing, but also identifies circumstances in which microbiological testing may play a useful role. It introduces the reader to a structured approach for managing food safety using control measures in three categories: (1) those that influence the initial level of the hazard, (2) those that cause reduction of the hazard and (3) those that prevent increase of the hazard during processing and storage. The concepts of

a Food Safety Objective (FSO) and a Performance Objective (PO) are recommended to industry and control authorities to translate risk into a definable goal for establishment of food safety management systems that incorporate the principles of GHP and HACCP. FSOs and POs provide the scientific basis for industry to design and implement measures to control the hazards of concern in a specific food, for control authorities to develop and implement inspection procedures to assess the adequacy of control measures, and for countries to quantify the equivalence of inspection procedures. In addition, the information on sampling plans presented in *Microorganisms in Foods 2* is updated and expanded.

This new book, *Microorganisms in Foods 8: Use of Data for Assessing Process Control and Product Acceptance*, consists of two parts: Part I, Principles of Using Data in Microbial Control, builds on the principles of *Microorganisms in Foods 7*. Part II, Application of Principles to Product Categories, provides practical examples for a variety of foods and processing environments. This material updates and replaces similar information presented in *Microorganisms in Foods 2*. Part II also builds on the second edition of *Microorganisms in Foods 6: Microbial Ecology of Food Commodities* (2005) by identifying additional tests to evaluate the effectiveness of controls.

Microorganisms in Foods 5, 6, 7 and 8 are intended for those involved in microbiological testing or engaged in setting microbiological criteria. These texts are useful for food processors, food microbiologists, food technologists, public health workers and regulatory officials. For students in food science and technology, the ICMSF series offers a wealth of information on food microbiology and food safety management, with many references for further study.

Microbiological testing can be a useful tool in the management of food safety. However, microbiological tests should be selected and applied with knowledge of their limitations, benefits, and the purposes for which they are used. In many instances other means of assessment are faster and more effective than microbiological testing for food safety assurance. The need for microbiological testing varies along the links of the food system, from primary production, to processing, to distribution and sale, to preparation, to point of consumption. Points in the food system should be selected where information about the microbiological status of a food will prove most useful for control purposes.

References

- ICMSF (International Commission on Microbiological Specifications for Foods) (1986) *Microorganisms in foods 2: sampling for microbiological analysis: principles and specific applications*, 2nd edn (1st edn published 1974). University of Toronto Press, Toronto
- ICMSF (1988) *Microorganisms in foods 4: application of the hazard analysis critical control point (HACCP) system to ensure microbiological safety and quality*, Blackwell Scientific Publications, Oxford
- ICMSF (1996) *Microorganisms in foods 5: characteristics of microbial pathogens*, Blackie Academic & Professional, London
- ICMSF (2002) *Microorganisms in foods 7: microbiological testing in food safety management*, Kluwer Academic/Plenum Publishers, New York
- ICMSF (2005) *Microorganisms in foods 6: microbial ecology of food commodities*, 2nd edn (1st edn published 1998). Kluwer Academic/Plenum Publishers, New York

Editorial Committee

- K. M. J. Swanson (Chair)
R. L. Buchanan
M. B. Cole
J.-L. Cordier
R. S. Flowers (2004–2008)
L. G. M. Gorris
M. H. Taniwaki (2009–2010)
R. B. Tompkin

Contributors and Reviewers

ICMSF Members During Preparation of this Book

Martin Cole (*Chair*), CSIRO, North Ryde NSW, Australia
Fumiko Kasuga (*Secretary*), National Institute of Health Sciences, Tokyo, Japan
Jeffrey M. Farber (*Treasurer*), Health Canada, Ottawa, Ontario, Canada
Wayne Anderson, Food Safety Authority of Ireland, Dublin, Ireland (from 2008)
Lucia Anelich, Anelich Consulting, Pretoria, South Africa
Robert L. Buchanan, University of Maryland, College Park, MD, USA
Jean-Louis Cordier, Nestlé Nutrition, Vevey, Switzerland
Susanne Dahms, Freie Universität, Berlin, Germany (to 2007)
Ratih Dewanti-Hariyadi, Bogor Agricultural University, Bogor, Indonesia (from 2008)
Russ S. Flowers, Silliker Group Corp. Homewood, IL, USA
Bernadette D.G.M. Franco, Universidade de São Paulo, São Paulo-SP, Brazil
Leon G.M. Gorris (*Secretary 2007–2010*), Unilever, Shanghai, China
Lone Gram (*Secretary to 2007*), Technical University of Denmark, Lyngby, Denmark (to 2009)
Anna M. Lammerding, Public Health Agency of Canada, Guelph, Ontario, Canada
Xiumei Liu, China CDC, Ministry of Health, Peoples Republic of China
Morris Potter, FDA Center for Food Safety and Applied Nutrition, Atlanta, GA, USA (to 2009)
Tom Ross, University of Tasmania, Hobart Tasmania, Australia (from 2008)
Katherine M.J. Swanson, Ecolab, Eagan, MN, USA
Marta Taniwaki, Instituto de Tecnologia de Alimentos, Campinas-SP, Brazil (from 2010)
Paul Teufel, Federal Dairy Research Center (retired), Kiel, Germany (to 2007)
Marcel Zwietering, Wageningen University, Wageningen, The Netherlands

Consultants During Preparation of this Book

Wayne Anderson, Food Safety Authority of Ireland, Dublin, Ireland (2006–2007)
Kirin N. Bhilegaonkar, Bombay Veterinary College, Bombay, India (2009–2010)
Ratih Dewanti-Hariyadi, Bogor Agricultural University, Bogor, Indonesia (2006–2007)
Peter McClure, Unilever, Milton Keynes, United Kingdom (2010)
Tom Ross, University of Tasmania, Hobart, Tasmania, Australia (2006–2007)
Cindy M. Stewart, PepsiCo, Hawthorne, NY, USA (2005)
Marta Taniwaki, Instituto de Tecnologia de Alimentos, Campinas-SP, Brazil (2008–2009)
R. Bruce Tompkin, Conagra (retired), Chicago, IL, USA (2005–2009)
Michiel van Schothorst, Nestlé (retired), La Tour de Peilz, Switzerland (2005)
Richard Whiting, Exponent Inc., Bowie, MD, USA (2005)

Contributors

The Commission sincerely thanks the following individuals for their contributions to development of this book.

2 Validation of Control Measures

Cindy M. Stewart, PepsiCo, Hawthorne, NY, USA
Richard Whiting, Exponent Inc., Bowie, MD, USA

18 Oil- and Fat-Based Foods

Peter McClure, Unilever, Milton Keynes, United Kingdom

22 Eggs and Egg Products

Todd McAloon, Cargill, Minneapolis, MN, USA

Appendix A Sampling Considerations and Statistical Aspects of Sampling Plans

Peter Sestoft, University of Copenhagen, Denmark

Reviewers

The Commission conducted extensive internal review of the chapters in this book. In addition, a call for external reviewers was issued to expand the basis for review. The Commission sincerely thanks the following individuals for reviewing chapters and improving this work.

1 Utility of Microbiological Testing for Safety and Quality

Mark Powell, USDA/ORACBA, Washington, DC, USA

2 Validation of Control Measures

Juliana M. Ruzante, Joint Institute for Food Safety and Applied Nutrition, College Park, MD, USA
Virginia N. Scott, FDA Center for Food Safety and Applied Nutrition, College Park, MD, USA

3 Verification of Process Control

Cristiana Pacheco, State University of Campinas, Campinas, São Paulo, Brazil
Donald Schaffner, Rutgers University, New Brunswick, NJ, USA
Richard Whiting, Exponent Inc., Bowie, MD, USA

4 Verification of Environmental Control

Joseph F. Frank, University of Georgia, Athens, GA, USA
Gerardo Guzmán Gómez, Universidad de Guadalajara, Guadlajara, Mexico
Andreas Kiermeier, SA Research and Development Institute, Adelaide, Australia
Joseph D. Meyer, Covance Laboratories Inc., Madison, WI, USA

5 Corrective Action to Reestablish Control

Susan Ranck, Kellogg Company, Lancaster, PA, USA
Virginia N. Scott, FDA Center for Food Safety and Applied Nutrition, College Park, MD, USA

6 Microbiological Testing in Customer-Supplier Relations

Scott Brooks, Yum! Brands, Branch, TX, USA
Alison Larsson, Market Fresh Food Testing Laboratory, Minneapolis, MN, USA
Skip Seward II, Conagra Inc., Omaha, NE, USA

7 Applications and Use of Criteria and Other Tests

Ivan Nastasijevic, World Health Organization EURO, Tirana, Albania

Ranzell Nickelson II, Standard Meat Company, Saginaw, TX, USA

Kelly Stevens, General Mills Inc., Minneapolis, MN, USA

Ewen Todd, Michigan State University, East Lansing, MI, USA

Erdal U.Tuncan, Silliker Inc., Homewood, IL, USA

8 Meat Products

James S. Dickson, Iowa State University, Ames, IA, USA

Ian Jensen, Meat and Livestock Australia, North Sydney, NSW, Australia

Ivan Nastasijevic, World Health Organization EURO, Tirana, Albania

9 Poultry Products

Dane Bernard, Keystone Foods LLC, Conshohocken, PA, USA

Marcos X. Sanchez-Plata, Inter-American Institute for Cooperation on Agriculture, Miami, FL, USA

10 Fish and Seafood Products

Beatrice Dias-Wanigasekera, Food Standards Australia New Zealand, Wellington, Australia

Lee-Ann Jaykus, North Carolina State University, Raleigh, NC, USA

Ranzell Nickelson II, Standard Meat Company, Saginaw, TX, USA

11 Feeds and Pet Food

Timothy Freier and David Harlan, Cargill, Minneapolis, MN, USA

Frank T. Jones, Performance Poultry Consulting, LLC, Springdale, AR, USA

12 Vegetables and Vegetable Products

Patricia Desmarchelier, FASM FAIFST, Pullenvale, Queensland, Australia

David E. Gombas, United Fresh, Washington, DC, USA

Mary Lou Tortorello, Food and Drug Administration National Center for Food Safety and Technology, Summit-Argo, IL, USA

13 Fruits and Fruit Products

David E. Gombas, United Fresh, Washington, DC, USA

Ewen Todd, Michigan State University, East Lansing, MI, USA

14 Spices, Dry Soups and Asian Flavorings

John Hanlin, The Kellogg Company, Battle Creek, MI, USA

Skip Seward II, Conagra Inc., Omaha, NE, USA

15 Cereals and Cereal Products

William H. Sperber, Cargill Inc., Minnetonka, MN, USA

Kelly Stevens, General Mills Inc., Minneapolis, MN, USA

16 Nuts, Oilseeds, Dried Legumes and Coffee

Philip Blagoyevich, The HACCP Institute, San Ramon, CA, USA

Linda J. Harris, University of California-Davis, Davis, CA, USA

Erdal U.Tuncan, Silliker Inc., Homewood, IL, USA

17 Cocoa, Chocolate and Confectionery

Philip Blagoyevich, The HACCP Institute, San Ramon, CA, USA

Michael Rissakis, Hellenic Catering SA, Attica, Greece

18 Oil- and Fat-Based Foods

Sandra Kelly-Harris and S. Matilda Freund, Kraft Foods, Glenview, IL, USA
Judy Fraser-Heaps, Land O'Lakes, St Paul, MN, USA

19 Sugar, Syrups and Honey

Bruce Feree, California Natural Products, Lathrop, CA, USA

20 Nonalcoholic Beverages

Peter Simpson, The Coca-Cola Company, Atlanta, GA, USA
Peter Taormina, John Morrell Food Group, Cincinnati, OH, USA

21 Water

Willette M. Crawford, FDA Center for Food Safety and Applied Nutrition, College Park, MD, USA

22 Eggs and Egg Products

Stephanie Doores, Pennsylvania State University, State College, PA, USA

23 Milk and Dairy Products

Roger Hooi, Dean Foods Company, USA
Paul Teufel, Federal Dairy Research Center (retired), Kiel, Germany

24 Shelf-Stable Heat Treated Foods

Rui M. S. Cruz, Universidade do Algarve, Faro, Portugal
Andy Davies, H.J. Heinz Company Limited, United Kingdom
Alejandro S. Mazzotta, Campbell Soup Company, Camden, NJ, USA

25 Dry Foods for Infants and Young Children

Daniel A. March, Mead Johnson Nutrition Company, Evansville, IN, USA

26 Combination Foods

Cheng-An Hwang, USDA/ARS/ERRC, Wyndmoor, PA, USA
Alejandro S. Mazzotta, Campbell Soup Company, Camden, NJ, USA

Appendix A Sampling Considerations and Statistical Aspects of Sampling Plans

Mark Powell, USDA/ORACBA, Washington, DC, USA