

Contents

Preface	xiii
Thierry BÉNÉZECH and Christine FAILLE	
Introduction	xv
Thierry BÉNÉZECH and Christine FAILLE	
Chapter 1. Cross-contamination of Food by Contaminated Surfaces	1
Graziella MIDELET, Thomas BRAUGE and Christine FAILLE	
1.1. Surface contamination.	3
1.1.1. Viable but non-culturable cells (VBNCs).	3
1.1.2. Persistence of strains in agroindustrial environments	3
1.1.3. Monitoring the effectiveness of C&D procedures	4
1.2. Examples of cross-contamination related CFI (collective foodborne illnesses)	5
1.2.1. L. monocytogenes.	6
1.2.2. Other pathogens involved in epidemics due to cross-contamination	7
1.3. Research of parameters affecting cross-contamination	8
1.4. Conclusion	10
1.5. References	10
Chapter 2. Implementation of HACCP – Surface Hygiene	17
Nadia OULAHAL, Sylvie PERRET and Denis BORNUA	
2.1. Introduction	17
2.2. The HACCP approach: a system based on seven main principles.	21
2.3. Implementation of the HACCP approach/12 steps	26
2.3.1. Step 1: food safety team or HACCP team	26
2.3.2. Step 2: description or characterization of the product = the scope of the study	27
2.3.3. Step 3: determining the intended use	29
2.3.4. Step 4: drawing up the flow/operation diagram	29
2.3.5. Step 5: confirm the flowchart	30

2.3.6. Step 6: conduct a hazard analysis and risk assessment	30
2.3.7. Step 7: determine CCPs and PRPs.	30
2.3.8. Step 8: establish critical limits for each CCP	31
2.3.9. Step 9: establish a CCP monitoring plan	31
2.3.10. Step 10: define corrective actions	31
2.3.11. Step 11: implement verification procedures	31
2.3.12. Step 12: establish a documentation system	32
2.4. A case study: application to a company that packages powders of several levels of sensitivity	32
2.4.1. Issue	32
2.4.2. Proposed approach	33
2.5. Conclusion	35
2.6. References	36
Chapter 3. Commercial Methods for the Detection of Surface Bacterial Contamination in the Food Industry	37
Thomas BRAUGE, Christine FAILLE and Graziella MIDELET	
3.1. Introduction	37
3.2. Microbial flora in the food industry	38
3.3. European regulations, standards and guides on surface analysis	40
3.4. Surface sampling tools	41
3.4.1. Impression methods.	41
3.4.2. Smear methods	43
3.5. Analysis methods of surface samples	48
3.5.1. Cultivation methods	51
3.5.2. Molecular methods	53
3.5.3. Immunological methods	55
3.5.4. Alternative methods	56
3.6. Conclusion	57
3.7. References	57
Chapter 4. Metals and Alloys in Food Environments	59
Audrey ALLION-MAURER	
4.1. Introduction	59
4.2. Metals and alloys	59
4.2.1. Stainless-steel families and their applications	59
4.2.2. Notions of corrosion and means of prevention	64
4.2.3. Other metallic materials	69
4.3. Suitability for food contact	70
4.4. Durability of materials	71
4.4.1. Suitability for soiling and cleaning	71
4.4.2. Chemical compatibility.	72

4.5. Conclusion	72
4.6. References	72
Chapter 5. Role of Surfaces and Microbial Phenomenon.	75
Anthony J. SLATE, Joels S. T. WILSON-NIEUWENHUIS, Joshua H. SPALL and Kathryn A. WHITEHEAD	
5.1. The complex interplay of surface properties and their modifications to prevent bacterial binding.	75
5.2. Introduction	75
5.3. Surface physicochemistry.	77
5.3.1. What is surface physicochemistry?	77
5.3.2. Theories and surface energy methods.	77
5.3.3. Physicochemical forces.	78
5.3.4. Surface energy modification	79
5.3.5. Physicochemistry in microbial attachment	79
5.4. Surface chemistry	82
5.4.1. Stainless steels	83
5.4.2. Surface heterogeneity.	84
5.4.3. Oxide layer	85
5.4.4. Titanium dioxide	85
5.4.5. Novel surface coatings	85
5.4.6. Release-based antimicrobial surfaces	86
5.4.7. Contact-based antimicrobial surfaces	87
5.4.8. Repulsion-based antifouling surface coatings	87
5.4.9. Superhydrophobic effect-based anticontact surfaces.	88
5.4.10. The effect of conditioning film on surface chemistry	88
5.5. Surface topography	90
5.5.1. Surface topography quantification.	90
5.5.2. Surfaces with undefined topographies	91
5.5.3. Surfaces with defined topographies	93
5.5.4. Biomimetic topographies.	95
5.6. Conclusion	99
5.7. References	99
Chapter 6. Hygienic Design – Factory	115
John HOLAH	
6.1. Introduction	115
6.2. Barrier 1: site.	118
6.3. Barrier 2: factory building	119
6.4. Barrier 3: basic to medium hygiene transfer and internal segregation.	122
6.5. Barrier 4: high hygiene areas	126
6.5.1. Structure	128

6.5.2. Heat-treated ingredients	129
6.5.3. Ingredient decontamination and transfer	130
6.5.4. Packaging	132
6.5.5. Personnel	133
6.5.6. Air	135
6.5.7. Utensils	137
6.5.8. Liquid and solid wastes.	138
6.6. Barrier 5: product enclosure	140
6.7. References	141
Chapter 7. Hygienic Design of Processing Lines	143
Franck MOERMAN and John HOLAH	
7.1. Introduction	143
7.2. Legislation, standards and guidelines covering hygienic design.	144
7.2.1. European legislation, standards and guidelines.	145
7.2.2. US legislation, standards and guidelines	145
7.3. Materials of construction	146
7.3.1. General recommendations	146
7.3.2. Metals and alloys	146
7.3.3. Use of plastics.	147
7.3.4. Rubbers	148
7.3.5. Other materials	148
7.3.6. Compatibility of materials of construction	149
7.4. Surface finish: hygienic design requirements	149
7.4.1. Product contact surfaces	149
7.4.2. Non-product contact surfaces	150
7.5. Hygienic joining of materials of construction.	150
7.5.1. Weld joints	150
7.5.2. Dismountable joints.	152
7.6. Assembly and disassembly of equipment	156
7.7. No accumulation and ingress of liquids, food residues and bacteria	157
7.7.1. Avoid horizontal surfaces	157
7.7.2. Avoid hollow areas	157
7.7.3. Avoid dead areas	157
7.7.4. Avoid extended T-pieces.	158
7.8. Correct mounting of sensors	160
7.9. Application of hoses.	160
7.10. Drainability of surfaces and equipment components	161
7.10.1. Drainability of equipment surfaces	161
7.10.2. Drainability of piping	161
7.10.3. Drainability of equipment.	162
7.11. Sufficient access for inspection, cleaning and disinfection	164

7.12. Framework	165
7.13. Feet	165
7.14. Hygienic design of belt conveyors	168
7.15. Hygienic design of open vessels (containers, bins, kettles).	170
7.15.1. Hygienic design of open vessels	170
7.15.2. Hygienic installation of agitators in open vessels.	171
7.16. Hygienic design of closed vessels	172
7.16.1. Fully drainable vessels with curved corners.	172
7.16.2. Lids and covers	173
7.16.3. Cleanable tank ports.	175
7.16.4. Top mounted installation of agitators	176
7.16.5. Hygienic design of permanently installed agitators.	177
7.17. Good insulation practices	179
7.18. Hygienic design of valves	179
7.19. Motors.	180
7.20. Hygienic design and installation of enclosures and control panels.	182
7.20.1. Hygienic design of maintenance enclosures.	182
7.20.2. Hygienic design of control panels	184
7.21. Covers and guards	184
7.21.1. Covers	185
7.21.2. Guards	188
7.22. Installation of the food processing equipment in the food factory	189
7.23. Platforms, walkways, stairs and ladders	191
7.24. Conclusion	193
7.25. References	194
 Chapter 8. Hygienic Design – Consequences on Surface Contamination and Cleaning	197
Thierry BÉNÉZECH and Christine FAILLE	
8.1. Introduction	197
8.2. Surface contamination.	197
8.2.1. Contamination of immersed surfaces	197
8.2.2. Contamination of interfaces between air, liquid and walls	200
8.3. Surface cleaning	202
8.4. Acknowledgments	204
8.5. References	205
 Chapter 9. Cleaning Operations – State of the Art	209
Hein TIMMERMAN	
9.1. Introduction	209
9.2. Soils.	210
9.3. Cleaning and disinfecting best practices.	210

9.4. Common cleaning and disinfection issues	213
9.5. Trends in cleaning and disinfection	215
9.5.1. Optimization of the pre-wash	215
9.5.2. Disinfection without rinsing is on the rise	215
9.5.3. Organic acids gain importance.	215
9.5.4. On site – in situ generation of biocides	216
9.5.5. IoT	216
9.6. Conclusion	217
Chapter 10. Novel Cleaning Methods	219
Heni DALLAGI, Piyush KUMAR JHA, Christine FAILLE and Thierry BÉNÉZECH	
10.1. Introduction	219
10.2. Mechanical action	220
10.2.1. Pulsed flow	220
10.2.2. Water jet	221
10.2.3. Ultrasound-assisted cleaning	222
10.2.4. Wet/dry-ice blasting.	224
10.2.5. Foam cleaning	225
10.2.6. Non-thermal plasma (NTP)/cold plasma	227
10.3. Chemical and biological cleaning methods	228
10.3.1. Electrolyzed water.	228
10.3.2. Enzymatic cleaning	229
10.3.3. Biosurfactants	231
10.4. Conclusion	232
10.5. Acknowledgments	232
10.6. References	233
Chapter 11. Surface Disinfection – State of the Art	239
Susana FERNANDES, Isabel OLIVERA, Inês B. GOMES and Manuel SIMÕES	
11.1. Introduction	239
11.2. Biocides for industrial application	240
11.2.1. Halogen-releasing-based compounds	242
11.2.2. Peroxygen-based compounds.	245
11.2.3. Organic acid-based compounds	247
11.2.4. Aldehyde-based compounds	248
11.2.5. Quaternary ammonium compounds	249
11.2.6. Alcohol-based compounds	251
11.2.7. Combination of biocides and methods.	251
11.3. Biofilm as a resistant or unsusceptible form to biocides	253
11.4. Conclusion	256
11.5. Acknowledgments	256
11.6. References	257

Chapter 12. Surface Disinfection – New Approaches	269
Isabel OLIVEIRA, Susana FERNANDES, Manuel SIMÕES and Inês B. GOMES	
12.1. Introduction	269
12.2. New disinfectants	271
12.2.1. Enzymes	271
12.2.2. Bacteriophages and endolysins	272
12.2.3. Quorum-sensing inhibitors	273
12.2.4. Essential oils and phytochemicals	274
12.2.5. Microbial cell metabolites	275
12.2.6. Nanoparticles	277
12.3. Improved methods for disinfection	278
12.3.1. Fogging or aerosolization	278
12.3.2. Hydrogen peroxide vapor systems	279
12.3.3. Gaseous ozone	279
12.3.4. Ultraviolet (UV) radiation	280
12.3.5. High-intensity narrow-spectrum (405 nm) light	281
12.3.6. Advanced oxidation processes (AOPs)	281
12.4. Self-disinfecting surfaces	281
12.4.1. Nanotechnology in food-contact surfaces	282
12.4.2. Antimicrobial-containing/realizing surfaces	285
12.5. Acknowledgments	287
12.6. References	287
Chapter 13. Food Safety in Supply Chains	301
Marc MAUERMANN, Andre BOYE, Max HESSE, Enrico FUCHS, Roman MURCEK, Vincent EISENRAUCH, Tilman KLAEGER and Jialiang YIN	
13.1. Food transport container	302
13.1.1. Hygienic design of food transport container	303
13.1.2. Cleaning of food transport containers	305
13.2. Technological approaches and innovation supporting food safety	313
13.2.1. Monitoring of cleaning processes	313
13.2.2. Adaptive cleaning devices	318
13.2.3. Cyber-physical cleaning processes	323
13.2.4. Demand for research and development	327
13.3. References	328
Chapter 14. Food Safety Risk Prevention at the Consumer Level	333
Gyula KASZA and Tekla Izsó	
14.1. Role of consumers in risk prevention – the last step in the food chain	333
14.1.1. How do consumers perceive food safety risks?	334
14.2. Insights into knowledge, awareness, attitudes in relation to consumers' behavior	337

14.2.1. Knowledge	338
14.2.2. Awareness	339
14.2.3. Attitudes	339
14.2.4. Risk communication paradigms	341
14.3. Preventive risk communication in practice.	342
14.3.1. Preparation for shopping	343
14.3.2. Good practices during shopping	344
14.3.3. Transportation of the food to the households	345
14.3.4. Food storage at home	346
14.3.5. Food preparation, cooking and serving	347
14.3.6. Handling leftovers	350
14.3.7. Advice for food producers	351
14.4. Future solutions for reducing risks at the consumer level.	352
14.5. References	353
List of Authors	361
Index.	365