
Contents

PART I *Surimi*

Chapter 1	Surimi Resources.....	3
1.1	Introduction	4
1.2	Cold-Water Whitefish Used for Surimi.....	5
1.2.1	Alaska Pollock	5
1.2.1.1	History of the Pollock Industry.....	5
1.2.1.2	Current Trends in Pollock Harvests.....	8
1.2.1.3	Management.....	11
1.2.2	Pacific Whiting.....	13
1.2.3	Arrowtooth Flounder.....	16
1.2.4	Southern Blue Whiting and Hoki	17
1.2.5	Northern Blue Whiting.....	19
1.2.6	Other Whitefish Resources (South America)	19
1.3	Tropical Fish Used for Surimi	19
1.3.1	Threadfin Bream (<i>Nemipterus</i> spp.)	20
1.3.2	Lizardfish (<i>Saurida</i> spp.).....	21
1.3.3	Bigeye Snapper (<i>Priacanthus</i> spp.).....	22
1.3.4	Croaker (<i>Sciaenidae</i>).....	23
1.3.5	Other Species.....	23

1.4	Pelagic Fish Used for Surimi	25
1.5	Conclusions: Changes in Surimi Supply and Demand.....	26
	References	29
	Chapter 2 Surimi: Manufacturing and Evaluation .....	. 33
2.1	Introduction .....	. 35
2.2	Processing Technology and Sequence .....	. 37
2.2.1	Heading, Gutting, and Deboning .....	. 37
2.2.2	Mincing .....	. 38
2.2.3	Washing and Dewatering .....	. 39
2.2.4	Refining .....	. 40
2.2.5	Screw Press.....	. 41
2.2.6	Stabilizing Surimi with Cryoprotectants .....	. 42
2.2.7	Freezing .....	. 44
2.2.8	Metal Detection .....	. 47
2.3	Biological (Intrinsic) Factors Affecting Surimi Quality.	. 48
2.3.1	Effects of Species.....	. 48
2.3.2	Effects of Seasonality and Sexual Maturity ...	. 49
2.3.3	Effects of Freshness or Rigor .....	. 52
2.4	Processing (Extrinsic) Factors Affecting Surimi Quality.....	. 53
2.4.1	Harvesting .....	. 53
2.4.2	On-Board Handling.....	. 55
2.4.3	Water .....	. 58
2.4.4	Time/Temperature of Processing.....	. 60
2.4.5	Solubilization of Myofibrillar Proteins during Processing .....	. 62
2.4.6	Washing Cycle and Wash Water Ratio .....	. 66
2.4.7	Salinity and pH.....	. 69
2.5	Processing Technologies that Enhance Efficiency and Profitability .....	. 76
2.5.1	Neural Network.....	. 76
2.5.2	Processing Automation: On-Line Sensors .....	. 80
2.5.3	Digital Image Analysis for Impurity Measurement.....	. 81
2.5.4	Innovative Technology for Wastewater .....	. 82
2.5.5	Fresh Surimi.....	. 84
2.6	Decanter Technology .....	. 86
2.7	Surimi Gel Preparation for Better Quality Control .....	. 91
2.7.1	Chopping .....	. 91
	2.7.1.1 2% and 3% Salt	. 92

2.7.1.2	Moisture Adjustment	92
2.7.1.3	Chopping Temperature	92
2.7.1.4	Effect of Vacuum	93
2.7.2	Cooking	93
2.7.2.1	Plastic Casing and Stainless Steel Tube	93
2.7.2.2	Cooking Method Resembling Commercial Production of Crabstick....	93
2.8	Summary.....	95
Acknowledgments.....		97
References		98
Chapter 3	Process for Recovery of Functional Proteins by pH Shifts	
3.1	Introduction	
3.2	Characteristics of Dark Muscle Fish Crucial to Surimi Processing	109
3.2.1	Dark Muscle	109
3.2.2	Lipids.....	113
3.2.3	Muscle Proteins	115
3.2.4	Processing of Pelagic Fish	117
3.2.4.1	Alkaline Processing.....	119
3.2.4.2	Problems with Processing Dark-Muscled Species.....	
3.3	A New Approach for Obtaining Functional Protein Isolates from Dark-Muscled Fish.....	123
3.4	Summary.....	132
References		133
Chapter 4	Sanitation and HACCP.....	141
4.1	Introduction	142
4.2	Sanitation.....	143
4.3	Good Manufacturing Practices (GMPs).....	144
4.4	Hazard Analysis Critical Control Point (HACCP).....	145
4.5	Principles of the HACCP System.....	146
4.6	HACCP for Surimi Production.....	148
4.7	HACCP for Surimi Seafood Production.....	149
4.8	Microbiological Standards and Specifications for Surimi Seafood	151
4.9	Sanitation Standard Operating Procedures (SSOPs).....	153

4.10 Cleaners and Sanitizers	154
4.11 Verification	158
References	161
Chapter 5 Stabilization of Proteins in Surimi	163
5.1 Introduction	164
5.2 Myosin and Fish Proteins.....	165
5.3 Stability of Myosin	166
5.3.1 Stabilization of the Globular Head Region	166
5.3.2 Helix-Coil Transition in the Myosin Rod	168
5.4 Intrinsic Stability of Fish Muscle Proteins	170
5.4.1 Influence of Animal Body Temperature	170
5.4.2 Naturally Occurring (Protecting and Nonprotecting) Osmolytes.....	172
5.4.3 Antifreeze Proteins	175
5.5 Stability of Frozen Surimi Proteins.....	176
5.5.1 Cold Destabilization.....	177
5.5.2 Ice Crystallization	177
5.5.3 Hydration and Hydration Forces	179
5.5.4 Other Destabilizing Factors during Frozen Storage.....	181
5.6 Mechanisms for Cryoprotection and Cryostabilization	184
5.6.1 Solute Exclusion from Protein Surfaces.....	184
5.6.2 Ligand Binding.....	188
5.6.3 Antioxidants	189
5.6.4 Freezing-Point Depression.....	189
5.6.5 Cryostabilization by High Molecular Weight Additives	191
5.6.6 Vitrification	195
5.7 Processing Effects on Surimi Stability	196
5.7.1 Fish Freshness	196
5.7.2 Leaching.....	197
5.7.3 Freezing Rate	197
5.8 Stabilized Fish Mince	198
5.9 Stabilization of Fish Proteins to Drying.....	201
5.9.1 Processes for Drying of Surimi	202
5.9.1.1 Freeze-Drying	202
5.9.1.2 Spray-Drying of Surimi	205
5.9.2 Potential Additives and Mechanisms of Lyoprotection	206

5.10 Future Developments in Fish Protein Stabilization	210
References.....	213

Chapter 6 Proteolytic Enzymes and Control in Surimi

227

6.1 Introduction	228
6.2 Classification of Proteolytic Enzymes.....	231
6.2.1 Acid Proteases (Lysosomal Cathepsins)	232
6.2.1.1 Cathepsin A.....	233
6.2.1.2 Cathepsin B.....	234
6.2.1.3 Cathepsin C (Dipeptidyl Transferase).....	235
6.2.1.4 Cathepsin D.....	236
6.2.1.5 Cathepsin E.....	237
6.2.1.6 Cathepsin H	237
6.2.1.7 Cathepsin L.....	238
6.2.2 Neutral and Ca ²⁺ -Activated Proteinases	241
6.2.3 Alkaline Proteinases	245
6.3 Sarcoplasmic vs. Myofibrillar Proteinases.....	249
6.4 Control of Heat-Stable Fish Proteinases.....	250
6.4.1 Proteinase Inhibitors	250
6.4.1.1 Inhibitors of Serine Proteinases	251
6.4.1.2 Inhibitors of Cysteine Proteinases	252
6.4.1.3 Inhibitors of Metalloproteinases	253
6.4.2 Food-Grade Proteinase Inhibitors.....	253
6.4.3 Minimization of Proteolysis by Process Control	259
6.5 Summary.....	260
References	260

Chapter 7 Waste Management and By-Product Utilization

279

7.1 Introduction	281
7.2 Surimi Waste Management and Compliance.....	283
7.2.1 Measurements Needed for Compliance.....	284
7.2.1.1 Accurate Wastewater Flow Meters....	284
7.2.1.2 Correct Measurement of Solid Concentration	285
7.2.1.3 Correct Reporting of Tonnage	286

7.2.2	How to Implement a Waste Management Program	286
7.2.2.1	Plant Audit and Mass Balance ..	286
7.2.2.2	Water Reduction/Reuse.....	287
7.2.2.3	Waste Solids Recovery	287
7.3	Solid Waste	288
7.3.1	Fish Meal and Fish Protein Hydrolysates	288
7.3.2	Fish Oil Recovery	290
7.3.3	Specialty Products.....	292
7.4	Surimi Wastewater.....	293
7.4.1	Chemical Methods.....	295
7.4.2	Biological Methods	297
7.4.2.1	Aerobic Process	297
7.4.2.2	Anaerobic Process	298
7.4.3	Physical Methods	299
7.4.3.1	Dissolved Air Flotation.....	299
7.4.3.2	Heat Coagulation	300
7.4.3.3	Electrocoagulation.....	301
7.4.3.4	Centrifugation	301
7.4.3.5	Membrane Filtration	303
7.5	Recovery of Bioactive Components and Neutraceuticals.....	306
7.5.1	Bioactive Compounds.....	306
7.5.1.1	Enzymes.....	307
7.5.1.2	Other Waste Compounds	309
7.5.2	Recovery of Bioactive Compounds	310
7.6	Opportunities and Challenges.....	311
7.6.1	The Limitations of Fish Solids Recovery ...	311
7.6.1.1	Quality Impediments	311
7.6.1.2	Environmental Limitations	312
7.6.1.3	Marketing Impediments	312
7.6.1.4	Proximity to Market	312
7.6.1.5	Labor and Maintenance Considerations.....	313
7.6.2	Current and Future Potential.....	313
7.7	Summary.....	315
	References	316
	Chapter 8 Freezing Technology.....	325
8.1	Introduction	326
8.2	Horizontal Plate Freezers.....	327

8.3	Airflow Freezers	331
8.3.1	Spiral Freezer.....	331
8.3.2	Tunnel Freezer	332
8.3.3	Blast Freezer	334
8.4	Brine Freezers	336
8.4.1	Sodium Chloride (NaCl)	337
8.4.2	Calcium Chloride (CaCl ₂)	337
8.4.3	Glycols	338
8.4.4	Other	338
8.5	Cryogenic Freezers	338
8.5.1	Liquid Nitrogen (LN)	339
8.5.2	Carbon Dioxide (CO ₂).....	340
8.6	Freezing the Product.....	342
8.7	Freezing Capacity.....	344
8.8	Freezing Time	347
8.9	Some "What-If" Effects on Freezing Time.....	356
8.9.1	Block Thickness	357
8.9.2	Cold Temperature Sink, T _a	357
8.9.3	Heat Transfer Coefficient, U	359
8.10	Energy Conservation.....	362
8.10.1	Freezer Design and Operation	363
8.10.2	Refrigeration Machinery Options	366
8.10.3	A Blast Freezer Case	367
8.11	Conclusions	368
	Acknowledgments.....	368
	References	369

PART II *Surimi Seafood*

Chapter 9	Surimi Seafood: Products, Market, and Manufacturing	375
9.1	Introduction	376
9.1.1	Surimi-Based Products in Japan and the United States.....	377
9.1.1.1	Japanese Market.....	377
9.1.1.2	The U.S. Market	380
9.1.2	Market Developments in France	383
9.1.3	Surimi Seafood Products in Other Countries.....	385

xx		Park
9.2	Manufacture of Surimi-Based Products .....	.. 388
9.2.1	Kamaboko .....	.. 388
9.2.2	Chikuwa .....	.. 390
9.2.3	Satsuma-age/Tenpura .....	.. 390
9.2.4	Hanpen .....	.. 392
9.2.5	Fish Ball .....	.. 393
9.2.6	Surimi Seafood .....	.. 395
9.2.6.1	Filament Meat Style .....	.. 396
9.2.6.2	Solid Meat Style .....	.. 417
9.3	Other Processing Technology .....	.. 419
9.3.1	Ohmic Heating .....	.. 419
9.3.2	High Hydrostatic Pressure .....	.. 424
9.3.3	Least-Cost Linear Programming .....	.. 425
Acknowledgments .....		.. 428
References .....		.. 430
Chapter 10	Surimi Gelation Chemistry	435
10.1	Introduction	436
10.2	Protein Components of Surimi	437
10.2.1	Myofibrillar Proteins	437
10.2.1.1	Myosin	439
10.2.1.2	Actin	441
10.2.1.3	Other Myofibrillar Proteins	441
10.2.1.4	Thick Filament Assembly	442
10.2.2	Stroma Proteins	444
10.2.3	Sarcoplasmic Proteins	444
10.2.3.1	Heme Proteins	446
10.2.3.2	Enzymes	447
10.3	Lipid Components of Fish Muscle	450
10.4	Bonding Mechanisms during Heat-Induced Gelation of Fish Myofibrillar Proteins	451
10.4.1	Hydrogen Bonds	451
10.4.2	Ionic Linkages (Salt Bridges)	452
10.4.3	Hydrophobic Interactions	455
10.4.4	Covalent Bonds	456
10.4.4.1	Disulfide Bonds	456
10.4.4.2	Rheological Behavior of Cross-Linked Protein Gels	459
10.4.4.3	Role of Disulfide Bonding in Myosin/Actomyosin Gelation	459

10.4.4.4	Covalent Cross-Linking during Setting.....	
10.4.4.5	Protein Stability Effects on Setting.....	
10.4.4.6	Endogenous Transglutaminase (TGase).....	468
10.4.4.7	Exogenous TGase Addition.....	469
10.5	Factors Affecting Fish Protein Denaturation and Aggregation.....	471
10.5.1	The Importance of Muscle pH (Acidity)	475
10.5.2	The Frozen Storage Stability of Surimi	476
10.6	Summary: Factors Affecting Heat-Induced Gelling Properties of Surimi	476
	References	477
Chapter 11	Rheology and Texture Properties of Surimi Gels.....	491
11.1	Introduction	493
11.2	Fundamental Test	496
11.2.1	Force and Stress	496
11.2.2	Deformation and Strain	498
11.2.3	Flow and Rate of Strain	499
11.2.4	Rheological Tests Using Small Strain (Deformation).....	501
11.2.4.1	Compressive Test for Surimi Gel.....	501
11.2.4.2	Shear Type Test for Surimi Paste and Gels	501
11.2.4.3	Stress Relaxation Test	503
11.2.4.4	Oscillatory Dynamic Test	508
11.2.5	Rheological Testing Using Large Strain (Failure Test)	518
11.2.5.1	Axial Compression for Cylinder Type Gels	519
11.2.5.2	Compressive Test for Convex Shape Samples	520
11.2.5.3	Compressive Test for Rod-Type Samples.....	521
11.2.5.4	Torsion Test	523
11.3	Empirical Tests.....	528
11.3.1	Punch (Penetration) Test	529

<i>xxii</i>		<i>Park</i>
11.3.2	Texture Profile Analysis (TPA).....	534
11.3.3	Relationship between Torsion and Punch Test Data	537
Effects of Processing Parameters on Rheological Properties of Surimi Gels.....		540
11.4.1	Effects of Fish Freshness/Rigor Condition.....	540
11.4.2	Effect of Refrigerated Storage of Gels.....	540
11.4.3	Effect of Sample Temperature at Measurement.....	541
11.4.4	Effect of Moisture Content	543
11.4.5	Effect of Low Temperature Setting.....	544
11.4.6	Effect of Freeze-Thaw Abuse.....	546
11.4.7	Effect of Functional Additives.....	546
11.4.8	Texture Map	548
Viscosity Measurements		549
11.5.1	Measurement of Dilute Extract	550
11.5.2	Measurement of Surimi Seafood Pastes.....	550
11.5.3	Rheological Behavior of Surimi Paste	556
Practical Application of Dynamic Rheological Measurements		558
11.6.1	Gelation Kinetics of Surimi Gels	559
11.6.1.1	Thermorheological Properties and Kinetic Model.....	559
11.6.1.2	Nonisothermal Kinetic Model	561
11.6.1.3	Rubber Elastic Theory.....	562
11.6.1.4	Dependence of Gelation Temperature on Moisture Content	563
11.6.1.5	Activation Energy during Gelation.....	565
11.6.2	Estimation of Steady Shear Viscosity of Fish Muscle Protein Paste	567
11.6.2.1	Steady Shear Viscosity of Surimi Paste and the Cox-Merz Rule	567
11.6.2.2	Superimposed Viscosity Using the Cox-Merz Rule.....	568
11.6.2.3	Concentration Dependence of the Viscosity of Surimi Paste.....	569
11.7	Summary.....	574
Acknowledgements		575
References		576

Contents

Chapter 12 Microbiology and Pasteurization of Surimi Seafood	
12.1 Introduction	585
12.2 Growth of Microorganisms in Foods	585
12.3 Surimi Microbiology	587
12.4 Microbial Safety of Surimi Seafood	590
12.4.1 <i>Listeria Monocytogenes</i>	591
12.4.2 <i>Clostridium Botulinum</i>	593
12.5 Pasteurization of Surimi Seafood.....	596
12.6 Process Considerations and Pasteurization Verification for Surimi Seafood.....	600
12.6.1 Principles of Thermal Processing to Surimi Seafood Pasteurization.....	601
12.6.2 D-Value.....	602
12.6.3 z-Value.....	602
12.6.4 F-Value (Lethality Value)	605
12.6.5 General Considerations for Heat Process Establishment or Verification.....	606
12.6.6 Study Design and Factors Affecting Pasteurization Process.....	607
12.6.7 Temperature Distribution Test Design.....	608
12.6.8 Heat Penetration Test Design	610
12.6.9 Initial Temperature (IT) and Product Size	611
12.6.10 Product Preparation/Formulation	611
12.6.11 Heat Resistance of Selected “Target” Microorganism	614
12.6.12 Analyzing the Pasteurization Penetration Data	617
12.7 Temperature Prediction Model for Thermal Processing of Surimi Seafood	624
12.8 Predictive Model for Microbial Inactivation during Thermal Processing of Surimi Seafood.....	626
12.9 New Technologies for Pasteurization: High-Pressure Processing and Electron Beam.....	628
12.9.1 High-Pressure Processing.....	628
12.9.2 Food Irradiation	629
12.9.3 Electron Beam	630
12.9.4 Electron Penetration in Surimi Seafood	631
12.9.5 Microbial Inactivation in Surimi Seafood	633
12.9.6 Effect of E-Beam on Other Functional Properties of Surimi Seafood.....	634

xxiv	Park
12.10 Packaging Considerations...	637
References	638
Chapter 13 Ingredient Technology for Surimi and Surimi Seafood	649
13.1 Introduction	650
13.2 Ingredient Technology	653
13.2.1 Water	653
13.2.2 Starch	657
13.2.2.1 What Is Starch?	657
13.2.2.2 Modification of Starch.....	657
13.2.2.3 Starch as a Functional Ingredient for Surimi Seafood	659
13.2.3 Protein Additives.....	668
13.2.3.1 Whey Proteins	669
13.2.3.2 Egg White Proteins.....	673
13.2.3.3 Plasma Proteins	676
13.2.3.4 Soy Proteins.....	677
13.2.3.5 Wheat Gluten and Wheat Flour.....	681
13.2.4 Hydrocolloids	681
13.2.4.1 Carrageenan	682
13.2.4.2 Konjac	683
13.2.4.3 Curdlan	684
13.2.4.4 Alginate.....	685
13.2.5 Cellulose.....	686
13.2.6 Vegetable Oil and Fat Replacer	686
13.2.7 Food-Grade Chemical Compounds	689
13.2.7.1 Oxidizing Agents	689
13.2.7.2 Calcium Compounds	689
13.2.7.3 Transglutaminase (TGase)	692
13.2.7.4 Phosphate	695
13.2.7.5 Coloring Agents	696
13.3 Evaluation of Functional Ingredients.....	699
13.3.1 Texture	699
13.3.2 Color	700
13.3.3 Formulation Development and Optimization	700
Acknowledgements	701
References	702

Chapter 14 Surimi Seafood Flavors.....	709
14.1 Introduction	710
14.2 What Is Flavor?	712
14.2.1 Creation of a Flavor	712
14.2.2 Natural Product Chemistry.....	713
14.2.2.1 Solvent Extraction	715
14.2.2.2 Gas Chromatography–Olfactometry (GCO)	716
14.2.2.3 Headspace Analysis	716
14.2.3 Building a Flavor	717
14.3 Basic Seafood Flavor Chemistry	720
14.3.1 Sources of Flavor Ingredients	720
14.3.1.1 Natural Extracts	720
14.3.1.2 Synthetic Components.....	721
14.3.2 The Importance of Lipids in Fish Flavors	721
14.3.3 Important Components Found in Seafood Extracts.....	724
14.3.3.1 Volatile Compounds	725
14.3.3.2 Nonvolatile Compounds.....	726
14.4 Additives and Ingredients Used in Flavors	727
14.4.1 Glutamate	728
14.4.2 Ribonucleotides.....	728
14.4.3 Hydrolyzed Proteins.....	728
14.4.4 Yeast Extracts.....	729
14.5 The “Off Flavors” of Seafood.....	730
14.6 Effects of Processing on Seafood	731
14.7 Flavor Release and Interactions	731
14.8 Effects of Ingredients on Flavor.....	733
14.8.1 Sorbitol and Sugar	734
14.8.2 Starch	734
14.8.3 Surimi (Raw material)	735
14.8.4 Egg Whites and Soy Proteins.....	736
14.8.5 Vegetable Oil	736
14.8.6 Salt	736
14.9 Processing Factors Affecting Flavors	737
14.9.1 Adding Additional Flavor/Flavor Components	737
14.9.2 Addition Points	737
14.9.3 Encapsulation	738
14.9.4 Storage Conditions and Shelf Life.....	738

<i>xxvi</i>	<i>Park</i>
14.10 Flavor Regulations and Labeling	739
14.10.1 United States.....	739
14.10.2 European Union (EU)	740
14.10.3 Japan.....	741
14.10.4 A Potential World List — The United Nations	742
14.10.5 Religious Certification Issues	743
14.10.6 Worldwide Issues.....	743
14.11 Summary.....	744
References	745

Chapter 15 Color Measurement and Colorants for Surimi Seafood .....	.. 749
15.1 Introduction	751
15.2 Understanding Color and Measurement.....	753
15.2.1 Development of Color Language	753
15.2.2 Color Space	754
15.2.3 Instrument Development.....	756
15.2.4 Tristimulus Values	756
15.2.5 L*a*b* Color Space	757
15.2.6 Indices	759
15.2.7 Measuring Color	759
15.2.7.1 Tristimulus Measurement.....	759
15.2.7.2 Spectrophotometric Measurement.....	762
Coloring Surimi Seafood	765
15.3.1 Preparation of Surimi Paste for Crabsticks	766
15.3.2 Color Application to Crabsticks	766
15.3.3 General Principles.....	766
Colorants	769
15.4.1 Colorants Requiring Certification	769
15.4.2 Colorants Not Requiring Certification	770
15.4.2.1 Carmine (21 CFR 73.100, EEC No. 120, CI No. 75470, CI Natural Red 4).....	770
15.4.2.2 Cochineal Extract (21CFR 73.100, EEC No. E120, CI Number 75470, Natural Red).....	770
15.4.2.3 Paprika (21CFR 73.345, EEC No. E 160c)	770

15.4.2.4	Annatto (21 CFR 73.30, EEC No. E 160b, CI 75120, CI Natural Orange 4).....	780
15.4.2.5	Turmeric (21CFR 73.600, EEC No. E 100, CI No. 75300, CI Natural Yellow 3).....	783
15.4.2.6	Grape Color (21CFR 73.169, EEC No, E163) and Other Anthocyanins	784
15.4.2.7	Beet Juice Concentrate (21CFR 73.260).....	785
15.4.2.8	Caramel (21 CFR73.85, EEC No. 150).....	786
15.4.3	Monascus Colorants	787
15.4.4	Nature Identical Colorants.....	787
15.4.4.1	Canthaxanthin (21 CFR 73.73.75, EEC No. E161g)	787
15.4.4.2	β -Carotene (21 CFR 73.95).....	788
15.4.5	Other Naturally Derived Colorants.....	788
15.4.5.1	Titanium Dioxide (E171, CI No. 77891, CI Pigment White 6).....	788
15.4.5.2	Calcium Carbonate (EE 170, CI No. 77220, CI pigment White 18).....	788
15.4.5.3	Vegetable Oil	789
15.5	Color Quality	789
15.5.1	Final Product Color.....	789
15.5.2	Colorant Quality.....	789
15.5.3	Acceptance Criteria.....	789
15.5.4	Acceptance Tolerance	792
15.6	Labeling.....	794
15.6.1	Requirements in the United States.....	794
15.6.2	Religious Requirements	795
15.7	Summary.....	796
	References	796
	Additional Reading	798
Chapter 16	Application of Sensory Science to Surimi Seafood	803
16.1	Introduction	805
16.1.1	What Is Sensory Evaluation?.....	805
16.1.2	Why Should We Care about Sensory Evaluation?	805

16.1.3	Brief History	806
16.1.4	Fundamentals of Sensory Evaluation	807
	16.1.4.1 Complex Nature of Sensory Measurement.....	807
	16.1.4.2 Sensory Perception Is More than Product Measurement.....	807
	16.1.4.3 Multidimensional Sensory Answer ..	809
16.2	Who Is Sensory Evaluation Working For?	811
	16.2.1 Research and Development (R&D)	811
	16.2.2 Production.....	812
	16.2.3 Marketing	812
16.3	Developing a Sensory Approach.....	813
	16.3.1 What Is the Problem?	813
	16.3.2 Sensory Human Resources	817
	16.3.2.1 Experimenter.....	817
	16.3.2.2 Panel	818
	16.3.3 Sensory Laboratory and Sensory Test Conditions	820
	16.3.3.1 Analytical Studies	820
	16.3.3.2 Hedonic Studies	822
	16.3.4 Sensory Tests	823
	16.3.4.1 Difference Tests	823
	16.3.4.2 Threshold Tests	823
	16.3.4.3 Descriptive Tests	824
	16.3.5 Statistics for Descriptive Analysis	826
	16.3.5.1 Basic Statistical Analysis	828
	16.3.5.2 Variance Analysis.....	828
	16.3.5.3 Multivariate Analysis	828
	16.3.6 Consumer Tests	828
	16.3.6.1 Declarative Methodologies	829
	16.3.6.2 Behavioral Methodologies	829
	16.3.7 Summary: Which Tests for Which Panelists?	831
16.4	Correlating Sensory Evaluation with Instrumental and Consumer Measures	832
	16.4.1 Why Is Instrumental Not Enough?	832
	16.4.2 Linking Consumer Data with Analytical Data: Preference Mapping Techniques	835
16.5	Conclusion: Sensory Evaluation from the Lab to the Consumers	837
	References	844

Chapter 17	New Developments and Trends in Kamaboko and Related Research in Japan.....	847
17.1	History of Kamaboko	848
17.2	Variations in Kamaboko Products in Japan	849
17.2.1	Steamed Kamaboko on a Wooden Board: Itatsuke Kamaboko	850
17.2.2	Grilled Kamaboko on Wooden Board: Yakinuki Kamaboko	851
17.2.3	Grilled Kamaboko on Bamboo Stick: Chikuwa	851
17.2.4	Deep-Fried Kamaboko: Age-Kamaboko	851
17.2.5	Boiled Kamaboko: Hanpen and Tsumire	852
17.2.6	Crab Leg Meat Analog, Crabstick: Kani-ashi Kamaboko or Kanikama	853
17.2.7	Fish Sausage and Ham.....	853
17.2.8	Other Kamaboko	853
17.3	Change in Fish Species Used for Kamaboko Production	855
17.4	Trends of Kamaboko Products: Quality, Variety, and Nutrition	857
17.5	Scientific and Technological Enhancement in Kamaboko in Japan during the Past 10 to 15 Years.....	859
17.5.1	Recent Progress in Gelation Mechanism	859
17.5.2	Recent Progress in the Understanding of Setting	860
17.5.3	Recent Progress in the Myosin Denaturation Study in Relation to Gelation	862
17.5.4	Myosin Rod Aggregation at High Temperature in Relation to Gelation	863
17.5.5	Biochemical Index for the Quality Evaluation of Frozen Surimi	865
References	866	
Appendix	Code of Practice for Frozen Surimi	869
Index	.....	887