

Contents

| | |
|--|-------------|
| List of Contributors | xi |
| Series Preface | xiii |
| Preface | xv |
| 1 Overview of Ocean and Aquatic Sources for the Production of Chemicals and Materials | 1 |
| <i>Francesca M. Kerton and Ning Yan</i> | |
| 1.1 Introduction | 1 |
| 1.2 Shellfish-Based Biomass | 3 |
| 1.2.1 Crustacean Shells | 3 |
| 1.2.2 Mollusc Shells | 7 |
| 1.3 Finfish-Based Biomass | 9 |
| 1.4 Plant-Based Biomass | 12 |
| 1.5 Summary and Outlook | 13 |
| References | 14 |
| 2 Production and Conversion of Green Macroalgae (<i>Ulva</i> spp.) | 19 |
| <i>Shuntaro Tsubaki, Wenrong Zhu and Masanori Hiraoka</i> | |
| 2.1 Production of <i>Ulva</i> Biomass | 19 |
| 2.1.1 Land-Based Tank Culture in Kōchi | 20 |
| 2.1.2 Improvement for More Intensive Culture | 25 |
| 2.2 Conversion of <i>Ulva</i> Biomass | 27 |
| 2.2.1 Microwave-Assisted Hydrothermal Reaction of Biomass | 28 |
| 2.2.2 Microwave-Assisted Conversion of <i>Ulva</i> Biomass | 29 |
| 2.3 Conclusions | 36 |
| References | 36 |

| | | |
|----------|---|-----------|
| 3 | A New Wave of Research Interest in Marine Macroalgae for Chemicals and Fuels: Challenges and Potentials | 43 |
| | <i>Ravi S. Baghel, Vaibhav A. Mantri and C.R.K. Reddy</i> | |
| 3.1 | Introduction | 43 |
| 3.2 | Macroalgal Feedstock for Chemicals | 44 |
| 3.3 | Marine Macroalgae as a Biorefinery Feedstock | 45 |
| 3.4 | Marine Macroalgal Biomass as an Energy Feedstock | 46 |
| 3.4.1 | Bioethanol | 47 |
| 3.4.2 | Biodiesel | 48 |
| 3.4.3 | Biobutanol | 48 |
| 3.4.4 | Bio-oil | 55 |
| 3.5 | Advances in Cultivation Technology | 55 |
| 3.6 | Marine Algal Cultivation for CO ₂ Sequestration | 56 |
| 3.7 | Opportunities, Challenges and Conclusions | 57 |
| | References | 58 |
| 4 | <i>Kappaphycus alvarezii</i>: A Potential Sustainable Resource for Fertilizers and Fuels | 65 |
| | <i>Dibyendu Mondal and Kamalesh Prasad</i> | |
| 4.1 | Introduction | 65 |
| 4.2 | Composition and Processing of <i>Kappaphycus alvarezii</i> | 66 |
| 4.3 | Simultaneous Production of Liquid Fertilizer (κ -Sap) and κ -Carrageenan from Fresh <i>Kappaphycus alvarezii</i> Seaweed | 68 |
| 4.4 | κ -Sap as Potential Plant Stimulant | 69 |
| 4.5 | Manipulation of κ -Sap for Sustainable Biomass Intensification of Maize | 71 |
| 4.6 | Bioethanol Production from <i>Kappaphycus alvarezii</i> | 72 |
| 4.6.1 | Pretreatment of Freshly Harvested Biomass | 74 |
| 4.6.2 | Hydrolysis of the Dry Biomass to Obtain Fermentable Sugars | 74 |
| 4.6.3 | Pretreatment of Hydrolysate to Reduce the Concentration of Fermentation Inhibitory Components | 74 |
| 4.6.4 | Enzymatic Fermentation of the Hydrolysate to Yield Ethanol | 76 |
| 4.6.5 | Purification of Ethanol from Fermentation Broth | 77 |
| 4.7 | Fuel Intermediates and Useful Chemical from <i>Kappaphycus alvarezii</i> | 77 |
| 4.8 | Environmental Impact of Fuel and Fertilizers Production from <i>Kappaphycus alvarezii</i> | 79 |
| 4.9 | Conclusion and Future Prospect | 79 |
| | Acknowledgement | 79 |
| | References | 80 |

| | | |
|----------|--|------------|
| 5 | Microalgae Bioproduction – Feeds, Foods, Nutraceuticals, and Polymers | 83 |
| | <i>Clifford R. Merz and Kevan L. Main</i> | |
| 5.1 | Introduction | 83 |
| 5.2 | Microalgae and Bioproduction Methods | 85 |
| 5.2.1 | Microalgae Groups Considered | 85 |
| 5.2.2 | Bioproduction of Microalgae – Methods | 86 |
| 5.3 | Microalgae Feedstock Products and Coproducts | 94 |
| 5.3.1 | Microalgae as Animal Feed | 94 |
| 5.3.2 | Microalgae as a Human Food Source | 95 |
| 5.3.3 | Microalgae in Nutraceuticals | 96 |
| 5.3.4 | Biopolymers from Microalgae | 98 |
| 5.4 | Conclusion – The Path Forward | 102 |
| | Acknowledgments | 103 |
| | References | 103 |
| 6 | Innovations in Crustacean Processing: Bioproduction of Chitin and Its Derivatives | 113 |
| | <i>Heather Manuel</i> | |
| 6.1 | Introduction | 113 |
| 6.2 | Innovations in Crustacean Processing | 115 |
| 6.2.1 | Conventional Processing Technologies | 115 |
| 6.2.2 | Innovations in Crustacean Processing | 122 |
| 6.3 | Utilization of Marine By-Products | 128 |
| 6.3.1 | Processing Technologies for Crustacean By-Products | 129 |
| 6.3.2 | A Biorefinery Approach for Value-Chain Optimization of Crustacean Biomass Waste | 130 |
| 6.4 | Bioproduction of Chitin and Its Derivatives | 132 |
| 6.4.1 | Background | 132 |
| 6.4.2 | Isolation and Extraction of Chitin and Chitosan | 134 |
| 6.4.3 | Non-chemical Structural Modifications of Chitin and Chitosan | 139 |
| 6.5 | Conclusions | 141 |
| | References | 143 |
| 7 | Recent Progress in the Utilization of Chitin/Chitosan for Chemicals and Materials | 151 |
| | <i>Bin Li and Xindong Mu</i> | |
| 7.1 | Structure, Source and Properties of Chitin/Chitosan | 151 |
| 7.2 | Isolation and Purification of Chitin/Chitosan | 153 |
| 7.3 | Derivatives of Chitin/Chitosan | 155 |
| 7.4 | Utilization of Chitin/Chitosan for Chemicals and Materials | 156 |
| 7.4.1 | Utilization of Chitin/Chitosan for Chemicals | 156 |

| | | |
|----------|--|------------|
| 7.4.2 | Utilization of Chitin/Chitosan for Materials | 170 |
| 7.5 | Closing Remark and Perspectives | 179 |
| | References | 180 |
| 8 | Characterization and Utilization of Waste Streams from Mollusc Aquaculture and Fishing Industries | 189 |
| | <i>Jennifer N. Murphy and Francesca M. Kerton</i> | |
| 8.1 | Introduction | 189 |
| 8.2 | Processing and Characterization of Mollusc Shells | 192 |
| 8.2.1 | Processing Technologies | 192 |
| 8.2.2 | Characterization of Shells | 195 |
| 8.3 | Applications of Mollusc Shells | 199 |
| 8.3.1 | Soil Amendment | 201 |
| 8.3.2 | Treatment of Metal Contamination and Acid Mine Drainage | 202 |
| 8.3.3 | Phosphate Removal and Water Purification | 208 |
| 8.3.4 | Building Materials | 212 |
| 8.3.5 | Mollusc-Derived Calcium Oxide in Catalysis | 219 |
| 8.4 | Conclusions | 224 |
| | References | 225 |
| 9 | Fish Processing Waste Streams as a Feedstock for Fuels | 229 |
| | <i>Kelly Hawboldt and Ibraheem Adeoti</i> | |
| 9.1 | Introduction | 229 |
| 9.2 | Fish Processing By-Product | 230 |
| 9.3 | Chemical and Physical Properties of Crude Fish Oil | 231 |
| 9.3.1 | Chemical Composition of Crude Fish Oil | 233 |
| 9.4 | Oil Recovery Processes and Parameters | 236 |
| 9.4.1 | Physical/Thermal Separation Processes | 236 |
| 9.4.2 | Chemical Extraction Processes | 238 |
| 9.4.3 | Biological/Chemical Hydrolysis and Fermentation | 244 |
| 9.4.4 | Purification | 245 |
| 9.4.5 | Preservation of Feedstock and the Recovered Oil | 246 |
| 9.5 | Fuel Properties of Crude and Refined Fish Oils | 247 |
| 9.5.1 | Rheological Properties | 247 |
| 9.5.2 | Chemical Properties Affecting Fuel Quality | 248 |
| 9.5.3 | Thermal Properties | 249 |
| 9.5.4 | Other Fuel Properties | 250 |
| 9.6 | Performance of Crude Fish Oil as a Fuel | 251 |
| 9.7 | Upgrading Marine Crude Bio-Oil | 251 |
| 9.7.1 | Types of Refined Fish Oil Products | 252 |
| 9.7.2 | Transesterification | 255 |
| 9.7.3 | Pyrolysis | 258 |

| | | |
|-------|---|-----|
| 9.7.4 | Microemulsification | 258 |
| 9.7.5 | Alternative Processes | 259 |
| 9.8 | Emission Comparison for Bio-Oils | 259 |
| 9.8.1 | Crude Fish Oil | 261 |
| 9.8.2 | Fish Biodiesel | 262 |
| 9.8.3 | Biogas from Fish Waste | 263 |
| 9.8.4 | Fish Biofuels from Other Processes | 264 |
| 9.9 | Comparison of Crude Oil and Refined Oil Performance as a Fuel | 265 |
| 9.10 | Comparison of Fish Biofuels | 268 |
| 9.11 | Summary | 268 |
| | References | 269 |

| | |
|--------------|------------|
| Index | 277 |
|--------------|------------|